The
GEOGRAPHICAL JOURNAL

Vol C No 4 R.G.S. *October 1942*

TEXAS OIL

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NO other natural product compares with petroleum in its influence on Western civilization during the last half century. In the last few years the importance to any country of conserving and extending its oil reserves has become only too clear. Vast amounts of time, energy, and money have therefore been spent on improving the technical methods by which oil may be found and recovered, both in districts known to be productive and in new regions.

Of the more accessible oil-yielding areas, none has had a more spectacular development than the Central Texas field. The state itself, the largest in the Union, is also its leading producer, with California in the second place. In 1941 Texas produced 500,241,199 barrels [1] of oil, twice the output of any other state, representing 35½ per cent. of the oil yield of the entire country. In 1939 the proportion was actually higher (39 per cent.), Texas furnishing almost a quarter of the world's total supply for the year. Even with oil selling at the well-head for only $1.10 per barrel, the revenue from this industry makes it by far the most important of the state. In 1941 new wells were drilled in Texas at the rate of 870 a month. The average depth (3627 feet) of these wells was over two-thirds of a mile, the aggregate footage drilled that year amounting to nine-tenths the diameter of the earth. On the average, every fourth bore-hole proved to be dry, and 1 in 37 yielded gas instead of oil. But before the year was out 7652 new wells were producing oil, thereby raising Texan production to date to the enormous total of 7,087,198,000 barrels.

In a state with some six hundred productive oil-fields and a yield more than twice that of all Russia, there naturally exist a range and variety of geological conditions that make generalization impossible. In the years immediately following the drilling of the first wells at Nacogdoches in 1887 fifty barrels was a good annual yield. By the turn of the century only thirteen years later the yield had leapt to 836,000 barrels, partly as the result of striking oil in the Gault Zone region which was later to achieve such importance. Meanwhile

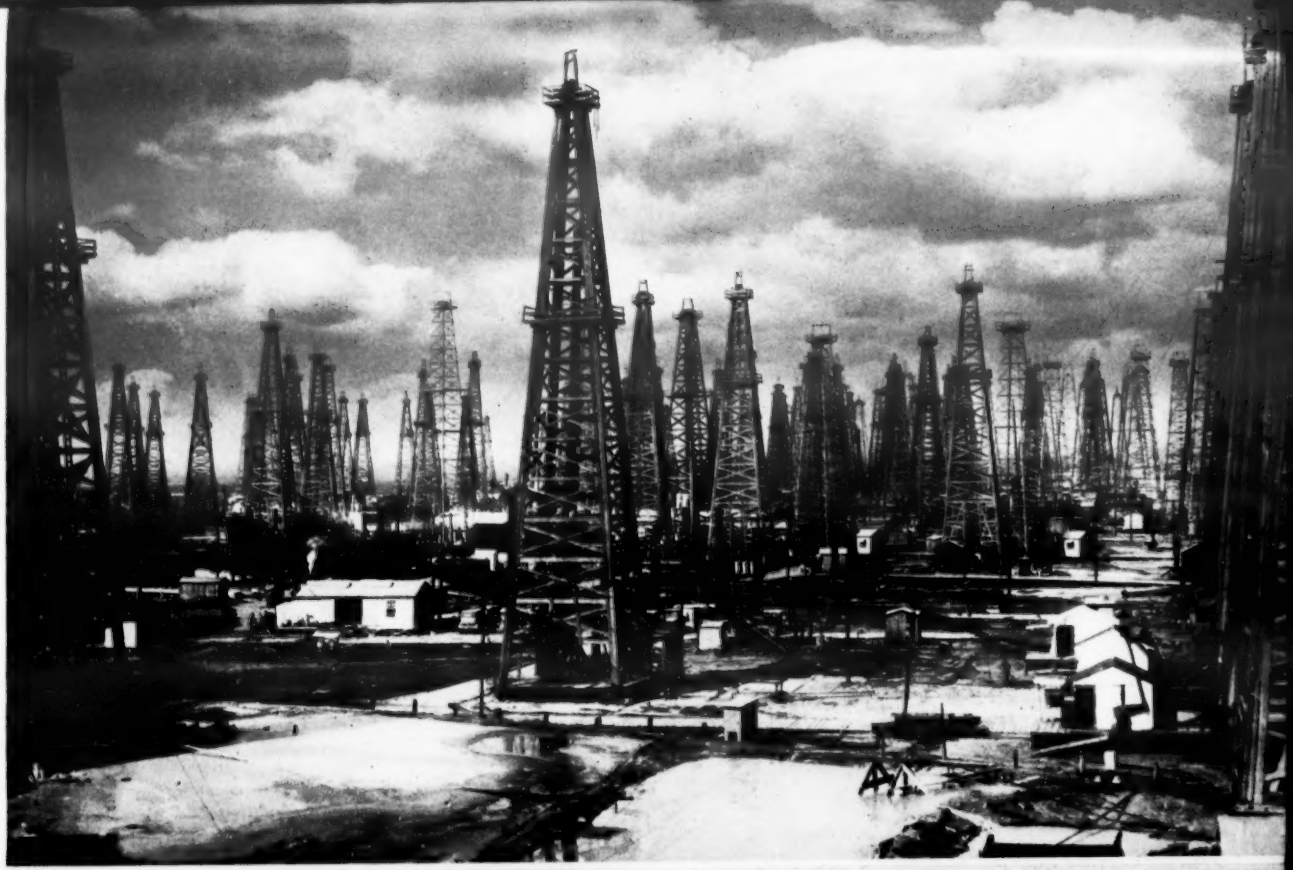
[1] The oil unit is the barrel of 42 U.S. gallons (equivalent to 35·6 Imperial gallons).

Captain Lucas, a retired Austrian Army officer, having noted that some oil alway seemed to show in brine wells close to the salt-domes on the Gulf Coast o Eastern Texas, staked his fortune on a drill-hole at Spindletop, a low flat topped hillock rising 10 feet above the plain, marking the site of a buried salt-dome near Beaumont. On 10 January 1901 the well came in at ove 25,000 barrels a day, estimates varying from 20,000 to as much as 100,000 Success was due in part to the courage and persistence of Lucas, but in par also to good luck in siting the drill-hole. Located 22 yards farther north-wes it would have been a dry hole, a fact which illustrates strikingly the impor tance of determining as exactly as possible the underground rock structure which control the presence of oil. The sensational proof of Lucas' salt dome theory as one of the ways in which oil may occur stimulated drilling activity. Within two-and-a-half years production reached 20,000,000 barrel and the price fell to an all-time low of five cents per barrel. North Texa came to life next, followed in 1921 by South and West Texas, and ten year later by East Texas.

Each of these regions has its own particular underground structura features which are studied with extreme care to discover clues that may guide prospectors to fresh fields. As soon as a boring strikes oil in a new locality, there is a rush to drill others nearby. Wells put down at a distance from any known producing structure, known to oil men as Wild-cat Wells are usually highly speculative, involving a gambling risk of from 1–6 to 1–1 or higher, according to the district. This risk has been steadily reduced, i is true, by increasing knowledge and by improved methods of prospecting In the early days the odds against striking oil were nearly 200 to 1. With growing appreciation of the connection between the presence of oil and directly observable geological structures, the risk was reduced to 16 to 1 To-day the chance of getting a dry hole is further halved by the delicate measurements of geophysical apparatus now employed by prospecting com panies to determine underground structures. These methods of "X-raying the earth's crust" depend on interpreting correctly the records of instrument which detect minute variations between different underlying strata in either specific gravity, magnetic attraction, electrical conductivity, or respons to artificial earthquake shocks. Supplemented by a familiarity with the thickness, fossil content, and detailed character of the various local formations by microscopic study of rock samples taken from the hole during drilling, and by Schlumberger "logs" of the changing resistance to the passage of electri current as the well deepens, these data reduce the hazards of wild-catting to reasonable proportions.

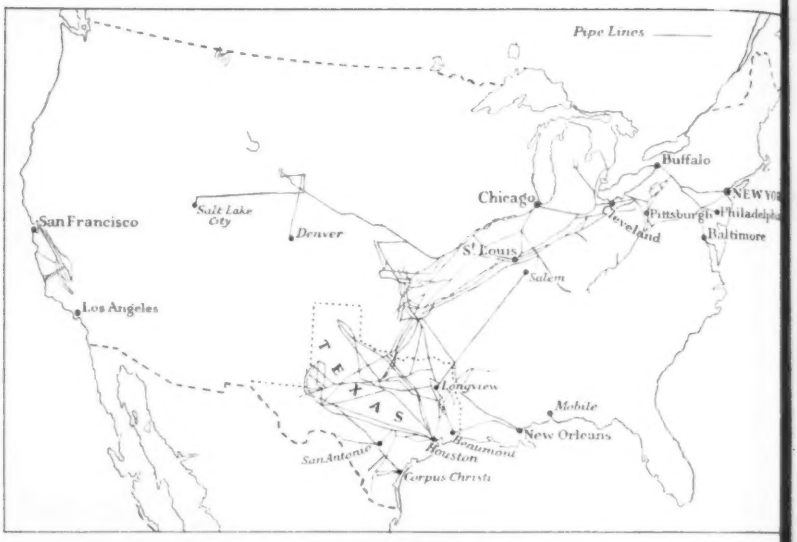
There is still dispute as to the precise way in which slowly acting natura processes, involving heat and pressure underground, have generated oil i droplets from minute marine organisms of past geological epochs and then caused its migration through the rocks from the place of origin to level where enough has accumulated to-day to form a workable oil-sand. There is however no longer question as to the types of underground structures mos commonly present where wells have struck oil.

Being formed from organic remains in ancient marine deposits, oil usuall



1. Derricks at Beaumont Field

Phot. Ewing Galloway



2. Crude oil pipe-lines

Phot. John

3. Air-view of Pampa Oil Field, North Texas, with derricks removed

ccurs associated with varying amounts of salt water and natural gas. Where ollected in sufficient quantities, these tend to separate into layers as they do n a tank, the oil above the water, and the gas rising to the top. The process f accumulation is extremely slow and, if the overlying rocks are porous, the il finds its way upwards to the surface and is dissipated without any quantity ollecting in one spot. Only where an impervious stratum hinders further pward progress will the oil accumulate. Water remains in the bottom of a asin only *below* the level of the *lowest* point of overflow. Rising oil and gas tay trapped beneath a domed capping of impervious rock only *above* the *ighest* point of escape, exactly as rising smoke in a room tends to linger near he ceiling in the upper air *above* the top of the highest open door or window. Thus a line traced round the under side of the impervious capping layer, evel with the highest point of escape, marks a "closure" which defines the naximum limits of the underground reservoir of oil in any particular oil-ield.

Unable to rise beyond the impermeable arch of overlying rock, oil trapped bove the level of closure becomes the victim of an increasing hydrostatic ressure, shared alike by the gas which is compressed and acts as does the as in a soda-water syphon to force the fluid up any open pipe plunged elow the liquid surface. Wells drilled into pressured structures flow freely n artesian fashion provided the bottom of the pipe lining the hole penetrates o the oil level (Plate 5). After a field has been worked for some months —the interval depending on the size of the pool, the initial pressure, and the umber and diameter of the wells—this compression diminishes and, unless estored artificially by forcing down gas or water into the field, is eventually xhausted, so that further recovery of oil is possible only by pumping it to he surface. It is obvious that wasteful escape of gas or oil from any well eans premature loss of pressure, and shortens the free-flowing life of all ells tapping the same field. Recently lessees of some South Texan fields ave resorted to a new method of ensuring a steady flow of oil, by forcing alt water down other holes in the field to the base of the producing formation n amounts calculated to maintain a constant bottom-hole pressure. In the lymouth field, for instance, 600 barrels of water are pumped down daily to depth of 5500 feet, thus offsetting the pressure lost by removal of oil through he flowing wells.

The most common structure likely to trap oil is an elongated dome or nticline formed where strata have been warped by slight or moderate crustal ressures. Another type of trap occurs where, instead of bending over in n arch, inclined strata are broken off and dragged down along a fault-face gainst which a closure is thus obtained. This structure may be produced ithout compressional crustal stresses.

Other natural oil-traps develop round the margin of salt plugs whose pward thrust has slowly pushed up clay-capped layers of sand, a structural elationship the importance of which was first realized thanks to Lucas' mous Spindletop discovery. More irregular oil reservoirs may occur where e sandy deposit instead of being a widely extended layer is lenticular or nforms to an old buried river channel, delta, or shoreline, later sealed over y an impervious covering of finer mud and silt. In gauging the probable

oil content of a trap of any of these varied types, oil men recognize the importance already mentioned of determining the closure made by the "lowest closing contour" on the under-surface of the impervious capping rock-stratum.

In December 1940 it was my good fortune to spend some days in the oil-fields of the San Antonio and Corpus Christi regions of South Texas with Professor Robert H. Cuyler of the University of Texas, who is himself responsible for the discovery of many of the producing fields.

These districts each illustrate not only one or more modes of occurrence of oil, but also many features common to other fields both in the methods of recovering it from the ground and of the subsequent handling of it, and in the complex problems of control, legislation, and taxation to which the precocious industry has given rise.

In the San Antonio region, the Balcones Zone is a gently curving strip of country 2–5 miles wide which is sliced across by a series of roughly parallel faults *en échelon* with the downthrow to the south-east. The strata involved range in age from Lower Cretaceous to Eocene. Younger formations of Tertiary and Quaternary age outcrop in parallel sequence nearer the coast, the whole series dipping gently seaward. The Balcones Zone is matched by a similar fault-belt farther east with the downthrow in the reverse direction. Referred to in general as the Mexia Zone, this latter falls naturally into sectors the most important of which is the Luling Area, south of Austin, the state capitol. The downfaulted strip between the two rift zones forms a graben, 20 or more miles wide and 200 miles long. In both belts the strata are dislocated by the fractures, with a maximum aggregate throw of 1000 feet near Austin on the Balcones Zone, and about half that amount in the Luling Area.

The Luling oil-field which gives its name to a district involving some thirty other fields, covers 2220 acres and has the structure of a faulted monocline affecting beds with a general south-easterly dip of less than 1° (100 feet per mile), thus trapping the oil in a long narrow reservoir 10 miles in length and 100–1000 yards wide. The fault itself is exposed in the stream banks where the San Marcos river cuts across the margin of the field, and here the dip can be seen to increase to 15° while on the downthrow side it attains 26° by reverse drag. Elsewhere the structure is interpreted largely from drill-cores.[1] Kelly No. 1, the deepest test pit in the field, struck pre-Cambrian schist at a depth of 7859 feet, indicating a total thickness of a mile and a half of sediment above the crystalline floor. The productive horizons tapped by the 736 wells in the Luling and adjoining Branyon fields lie at a depth of over 2200 feet.

The Gulf Coast region of South Texas involves a greater variety of oil-yielding structures than the Luling Area. Besides simple anticlines (as in Corpus Christi and Robstown fields) and domes (Agua Dulce), and faulted anticlines (McFaddin), domes (Midway), and monoclines (Coleto), there are structural traps formed by petroliferous lenses of sand, interlayered with relatively impervious finer sediments flanking deeply buried domes and

[1] Ernest W. Brucks, "Structure of typical American oil fields," *Amer. Ass. Pet. Geol.*, 1 (1929) 256.

arches (Greta, Refugio Fox, and Aransas Pass fields). The sand lenses represent Oligocene and Miocene shallow-water deposits, probably of beach or deltaic origin, which were successively sealed over by layers of silt and clay. In the Bentonville-King field, for instance, the distribution of the sand masses is suggestive of an old shoreline dating from the Frio stage of Upper Oligocene times. The petroliferous formation in the Tom O'Connor field has the outlines of an offshore bar.

As pointed out already, the formations of South Texas dip seawards. In consequence, to strike the same horizons, wells must go deeper as the coast is approached. Thus the base of the Catahoula formation which caps the Frio deposits outcrops at the surface 70 miles inland and is 5000 feet below ground-level at the coast, while in the Saxet field, 5 miles west of Corpus Christi, the Frio itself yields oil from depths of over 9900 feet.

With the need to drill wells of such depth, improved technical methods are constantly being devised. Many of these are already in use in other parts of the world. The traditional drilling tool is a weighted 5-foot bit on the end of a cable hung from a "walking beam" which is raised and lowered by a crank powered from the engine house. With each swing of the beam 2 tons or more of steel are raised several feet and allowed to fall again on the bottom of the hole, pulverizing the rock by the impact. In hard rock 10 feet a day may be good progress. In the softer formations of Texas a drill crew may make as much as 100 feet in 24 hours. A considerable fraction of the time must be spent in drawing the tools to replace worn bits and bale out the hole. After the hole has been bored it is usually lined with a casing of steel pipe to prevent its caving in and to exclude water from higher levels.

To-day much of the drilling is done with a rotary rig, the bit being screwed to the end of a rigid, jointed "drill-pipe" connected to a revolving turntable on the derrick floor. When the table turns, rotary motion is transmitted to the bit in the bottom of the well. As the hole deepens, the drill is lowered by screwing new sections to the top of the drill-pipe. To secure accurate sampling of the formations penetrated, a tubular bit is used and its core borings salvaged for examination. Each time the tools are withdrawn to change the bit or remove the core, the entire drill-pipe must be unscrewed in sections of three or four joint-lengths. The longer the joints used, the fewer the number of sections to be unscrewed per 100 feet of depth bored, and the greater the saving of time. Hence in recent years joints up to 40 feet in length have come into use, and derricks to suspend them during drilling operations are built correspondingly higher. But even with a derrick 180 feet high using maximum four-joint sections, changing the bit in a 5000-foot hole calls for more than thirty lifting operations each time the tools are withdrawn and sections unscrewed, and as many steps are needed to reassemble the drill. As the hole deepens, drawing tools becomes a still more tedious and risky business, with a mile of heavy piping to be lifted and expertly lowered without accident.

With a new premium on speed in drilling, anything which reduces the need to draw tools makes for earlier oil production. Where the sequence of formations and productive horizons are sufficiently known, the use of a Schlumberger resistance log gives a continuous electric record of the strata

drilled through so that direct sampling is obviated. After the hole has bee drilled to the lowest producing level and the casing set and cemented in plac a perforator is lowered to puncture the piping exactly at each of the productiv horizons, either by punching holes through it mechanically or by firin pointed steel bullets from a battery of cartridges directed radially outward so as to penetrate the casing and admit oil into the well. Using this metho crews have drilled holes 9000 feet deep in less than three weeks and in so strata records of 1500 feet in the first twenty-four hours have been possibl even with piping of 21-inch diameter. Frequently the drilling of a hole doe not of itself immediately open up a tight productive oil sand sufficiently t release a strong flow of oil, so that a charge of explosive has to be fired in th bottom of the well to crack open the surrounding rock and afford easie outlets for the imprisoned oil. When a well has to be "shot," risk of fir damage is reduced by first moving the drilling rig bodily on skids out of th danger zone, as has been done in the case of the flowing well shown i Plate 5.

The pressure generated in many of these fields introduces one of the speci hazards of drilling since, once the roof of the trap is punctured by drilling the force of escaping oil may blow the whole equipment sky-high and th well get out of control. If the casing is badly set or not cemented in place, th gas or oil may find an alternative escape outside the casing and burst a ne vent for itself forming a huge crater at the surface. These dangers are no so well recognized that in modern drilling blow-outs seldom occur except a the result of carelessness or poor management. Before the oil is allowed t enter the well, the casing is firmly anchored to a heavy platform at groun level and the standard equipment has a valve which not only can be shut a will, but closes automatically if a hurricane strikes the surface equipment an superstructure. Even so, occasionally a well runs wild and may in additio catch fire. Plate 4 shows the last stages in the usual method of snuffing ou a blazing well. The extinguisher which is about to cap the well hole has valved blow-hole or chimney in the centre. Once the cap is in place it ca be anchored firmly down and the valve then turned off. In some cases a ne hole is drilled obliquely from a point some distance away, directed to strik the miscreant well some distance below the surface. This taps and diver the oil below the point at which it reaches the air and ignites, thus giving chance to bring the well under control. In view of the risk of fire to every thing in the oil-drenched neighbourhood, the Government sets a penalty o one thousand dollars for each day that a well is not brought under contro As far as could be learned, this fine is seldom if ever actually collecte because every effort is immediately made to snuff a wild well with th greatest dispatch.

When an underground reservoir is tapped by a well and oil drawn off, th supply remaining is gradually reduced. As this reserve diminishes, wel on the limb of the anticline play out first and furnish only salt water. Wel on the crest of the arch promise the longest life, but in time they too will ru dry as the "pool" is exhausted. To prevent the holders of leases right on th crest from crowding their land with derricks so as to grab all the oil immed

Phot. L. H. Tiffin

4. Capping a blazing well in Ector County, Texas

5. Gusher, brought in by shooting after removing rig

Phot. G. B

6. Asphalt coating and spiral wrapping being applied to gas trunk

Phot. Ewing Ga

7. Aligning sections of Texas–Illinois twenty-six-inch gas trunk line

tely and thus bankrupt their less fortunate neighbours on the right and left who have drilled out on the limbs of the structure, public opinion demanded egislation to put a curb on selfish exploitation, over-production, and waste.

The need for some kind of stabilizing influence was first felt in the western part of the state when the drill-hole known as Marathon No. 38 suddenly came in at a depth of 1048 feet with 204,000 barrels a day, throwing the market into panic. As a result West Texas adopted a self-imposed proration system. With the subsequent development of East Texas fields prorationing became compulsory for the entire state. A special authority was set up to regulate the industry, and it became a special function of the Texas Railroad Commission to follow the market fluctuations, study the changing conditions in the various oil-fields, decide for each just how close adjoining derrick platforms may be set, and fix the rate at which oil may be taken from leases in any locality. All oil over and above the allowable monthly quota must be left in the ground and may not even be drawn off into storage tanks, under penalty of severe fine.

According to the 1942 estimate of the Texas crude oil reserve the amount still in the ground and therefore ultimately available exceeds the huge total of 10,623,516,000 barrels—or nearly 56 per cent. of the whole reserve of the United States.

In December 1941 the "net daily allowable" set for the entire state by the Texas Railroad Commission was 1,555,192 barrels. Following the declaration of war by the United States, the Office of the Federal Petroleum Coordinator in Washington recommended an increase in production, and the January 1942 allowable amount for Texas was therefore raised by 65,467 barrels a day. This was done simply by reducing the number of days in the month on which "shut-downs" are in force, and by permitting three fields to increase their allowable by about one-half. The second method of control by which the Commission stabilizes production is by enforcing a standard of well-spacing to prevent drill-holes from being crowded so close together on a small lease that its owners capture more than their fair share of the oil and drain the ground beneath adjoining leases.

In the older fields the concentration of wooden derricks often resembles a forest, like that at Beaumont in the years following the Spindletop oil rush (Plate 1). By regulating the minimum area marked off for each well, the law distributes the yield equitably over all wells in the field and equalizes to some extent the profits made by the various lessees. In contrast with the older unregulated location of wells is the orderly appearance of the landscape due to controlled siting and to the use of removable derricks seen in the air view (Plate 3) of a younger field in North Texas. The area shown is more than a mile in width and the fifty pale spots arranged in regular pattern mark the sites of as many wells. Faint lines radiating from a centre in the upper right quarter of the field are paths following the steel rods by which mechanical power is transmitted from the engine house to the surrounding well-head pump levers.

The initial costs of drilling and casing a well run high, and with the demand for steel by munitions factories, questions of priority have recently become acute. As a war economy measure, the Federal authorities ruled that all new

wells drilled after 1 January 1942 must adopt a 40-acre spacing instead of the previous 20- or 10-acre checkerboard. Doubling the minimum acreage per drill-hole halves the equipment needed and thus saves steel to the extent of at least thirty-two well rigs per square mile. This plan will no doubt be subject to local modifications, especially in "shoe-string" fields (and even in ones like Luling) which are so narrow that a 40-acre pattern might space the wells too far apart for effecting draining of the underground reservoir. Oil under pressure in the ground moves through a porous stratum or "sand" towards any point where that pressure is reduced by being tapped, and in migrating it has "no conscience about crossing property lines." In consequence there is a general agreement not to drill within 200 feet of the boundary-line so as not to drain the ground beneath the adjoining property.

Moreover as the oil company does not own the ground but only leases from the landowner the right to drill on it, it is clear that by failing to take up this option, or by delay in starting to drill until after adjoining leases are being worked, the company deprives the owner of his legitimate royalty on the yield. By common consent the terms of lease require the lessee to start drilling an "offset well" as soon as possible after a producing well is put down on an adjoining property. This offset well must be drilled on a site symmetrical, relative to the common boundary line, with the first drill-hole. Diagonal offsets are the counterparts when the symmetry is across the corners of a property instead of across the side-lines. Hence the regular space pattern of well sites in Plate 3.

The percentage of gas drawn off with the oil from any well varies greatly from field to field. If the oil-gas ratio is less than 1/100,000 it rates as a gas well. Any higher proportion of oil classifies it as an oil well. With oil wells, the gas ratio is so low that the gas is usually allowed to escape into the air. But in "wet-gas" fields production of the full oil quota involves so heavy an overproduction of gas that it raises a fresh difficulty, since the companies may neither pipe it away for sale, let it escape into the air, burn it, nor convert it to carbon-black unless it is first completely dried of oil. This problem is specially acute in the Gulf Coast districts where wet-gas wells are abundant. As an alternative to leaving it in the ground, several companies have recently erected recycling plants to handle the well yield, separate the oil, and pump the gas back into the ground, thereby maintaining the gas pressure in the field. The largest recycling plant visited was that of the Coastal Company in the Agua Dulce field near Corpus Christi. This plant, needing only four crews of three men each to run it continuously, deals with the entire production of one field and puts back into the ground 150 million cubic feet of gas daily. At the time of my visit, the net profit on the salvaged oil was $3700 per day.

As the temperature of the earth's crust in this part of Texas increases approximately 1½° F. for each additional 100 feet in depth, gas from a 6000-foot well-hole comes up at a temperature of 170° F. under a pressure of 80 atmospheres. The wet gas comes under its own pressure from the field to the central recycling plant, and is led into the bottom of three towers where it rises against a downward current of cool oil flowing over a series of baffles. This condenses the vaporized oil from the hot wet gas, which, cooled and

stripped of its oil content, is sucked as dry gas into compressors which force it back down wells in the heart of the field under a pressure nearly twice that at which it came up. The retrieved oil is distilled off at three temperatures and is then pumped by pipe-lines to the docks on the coast or into the cross-country distribution system. To minimize the risks of explosion or other emergency, the entire plant at Agua Dulce is under a special system of safety control which within twenty seconds completely shuts off circulation, stalls all pumps, motors, and other machinery, and opens a valve releasing the pressure to the air.

The unsuspectedly significant further discovery which the new technique has revealed is, that by flushing the field continuously with dry gas in this manner and abstracting the absorbed oil from the returning wet gas, a much more complete recovery of oil is possible than was heretofore realized. Previously, as oil and gas were drawn off, the underlying water-level rose, preventing the release of much of the oil film lining the pore-spaces of the petroliferous sediment. By repressuring the field, the water is held down until the gas has had a chance to absorb and remove a maximum quantity of the oil, thus greatly increasing the total recovered and prolonging the life of the field.

Among the bye-product industries is that of carbon-black of which Texas produces over 500,000,000 lbs. a year. Of this, four-fifths is used in the rubber industry, the balance finding its way into ink, paint, and miscellaneous commodities.

Two other vital phases of the oil industry: those of refining and distribution, have seen equally spectacular developments in recent years. The problems of refining are outside the scope of this paper. It is sufficient to mention that in the recycling plant at Agua Dulce the oil taken from the wet gas is fractionated directly by cooling at three temperatures, the high octane gasoline distillate for aviation being separated and pumped by a powerful force pump through pipe-lines direct to the Corpus Christi dockyards. Even the water removed in the process is not wasted, but goes at once into circulation in the cooling towers.

During the world crisis the problem of distribution has become critical. Up to the outbreak of war the bulk of the Texas output destined for the Atlantic coast went by sea. Thereafter many of the coastal tankers had to be diverted to meet needs overseas. With the growth of the submarine menace came a new realization of the importance of overland transportation. While much oil still travels by rail on tank cars, it has long been recognized that pipe-lines are the most direct and efficient means of distribution. Moreover, as pointed out by a Washington spokesman, "a pipe line cannot be sunk." The map (Plate 2) shows the extensive web of crude oil trunk lines whose total length is sufficient to circle the globe four times. By January 1942 the south-western systems included over 37,000 miles of gathering and distributing pipe-lines. The corresponding continental network of pipe-lines for natural gas has an aggregate length of 190,000 miles.

The urgent need for the rapid extension of trunk lines called for new developments in high-speed methods of pipe laying, involving careful pre-

paration and expert team work. As soon as the surveyor has staked out the line, "right-of-way men" strip the trees and underbrush, clearing a swathe wide enough to allow the passage of trucks and crews on either side of the survey line. Elephantine trucks loaded with lengths of pipe are then driven alongside every few feet to discharge their load, length by length. Although this is done in an apparently casual, carefree manner, each joint actually lands within a foot or two of its final resting place. Next, a reptilian pipe-laying tractor lumbers alongside or astride the pipes. It lifts them by slings, aligns and lowers them, touching end-to-end, on to blocks or skids so that they are clear of the ground (Plate 7). Gangs of welders follow with an electric generator mounted on a caterpillar tread. In high-speed work a first gang tack-welds the joints for a distance of 200 feet so that piping of that length can be handled as a unit, rolled slowly over and carefully welded by a second team, one welder being detailed for each joint.

In their wake travels an antediluvian-looking trio: a pair of tractor cranes to sling the pipe into a horizontal position 6 feet above the ground, and between them a wrapping machine which sprays and coats the pipe with hot asphalt and then immediately binds it spirally with tar paper. Before it is lowered a sickle-shaped metal brush attached to a high-tension generator is pressed along against the wrapping so that the sizzle of tell-tale sparks may reveal any poorly insulated spot. The pipe is scoured clear of debris and tested under pressure for leaks or faulty welds. Meanwhile if the ground permits it a ditching machine has channelled a trench, twice the width of the pipe, 2–6 feet deep. Otherwise it is dug by hand. Pipe-layers lower the line to its final resting place, burial usually taking place early in the day before the sun has a chance to heat and expand the metal too much for the pipe to lie straight in its trench. Caterpillar scrapers or bull-dozers back-fill the trench with the excavated material. The pipe-line is ready for use.

By midsummer 1942 the tanker tonnage lost at sea had become ominous. The volume of rail-transported oil on tank cars had risen to 700,000 barrels per day. Congress was at last ready to act on proposals which had been shelved for over a year and speedy action was secured on a plan to coordinate and extend the pipe-line network feeding the Atlantic coast ports. The biggest single item was a $35,000,000 pipe-line from Longview in north-east Texas across Arkansas to Salem in southern Illinois, a distance of 550 miles, equal to that from Paris to Berlin, to be laid within a period of five months. Ten motor-driven pumps, installed at 55-mile intervals, are powered to transmit 300,000 barrels daily. It takes two weeks to fill the 24-inch pipe, since $3\frac{1}{2}$ million barrels must go in at the Texas terminal before the first gallon can be delivered at the other end. To furnish the supply required, the flow in distributaries which previously carried oil from East Texas to the Gulf ports at Houston, Beaumont, and Port Arthur will be reversed, and pumps on the pipe-lines which were laid to carry tanker oil from New York and Philadelphia inland to Buffalo and Pittsburg will be similarly reversed so as to deliver "overland oil" to the seaports. Other changes in the redistribution plans call for seven relocations of old pipe-lines to increase the flow Atlantic-wards by a further 200,000 barrels daily, special processes being devised to recondition the old pipes.

A new gas-line connecting Larette in Louisiana with the port of Mobile in Alabama, 200 miles away, crosses the bed of the Mississippi and then for 25 miles lies on the floor of Lake Pontchartrain, so as to short-circuit a much longer detour across swamp land. Laying this lake-bed pipe was itself no small feat, the sections being welded on shore into lengths of 2500 feet and proofed against attack from brackish water before being floated into place, suspended from caissons, and then jointed together on the laying ship before being gently submerged to their final resting place on the bottom.

Most of these recent developments which were brought about to meet the war emergency will, like the spreading network of high-tension power lines, become part of the permanent post-war economy and are destined to play important roles in the peace-time welfare of the petroleum industry in days to come.

NOTES ON ALEXANDER'S CROSSING OF THE TIGRIS AND THE BATTLE OF ARBELA

SIR AUREL STEIN, K.C.I.E., F.B.A.

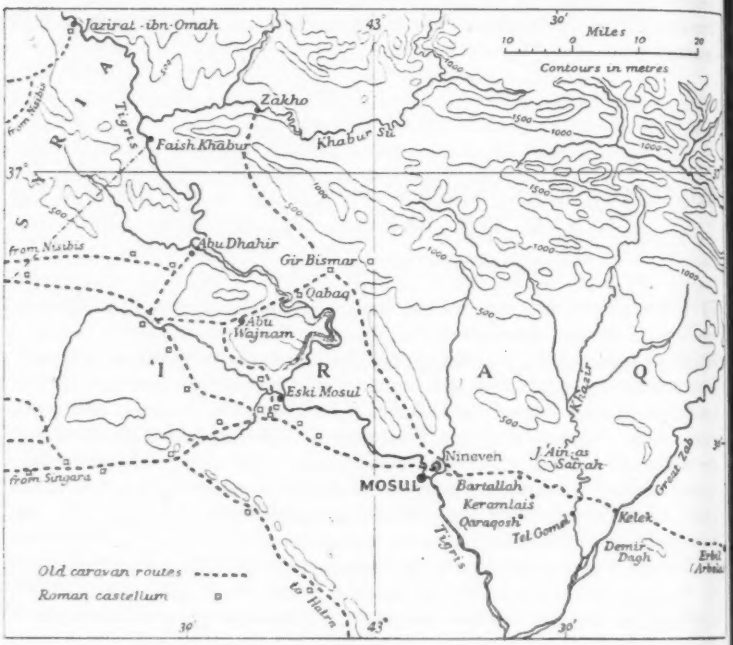
THE explorations I was able to devote in 1938 and 1939 to a survey of Roman frontier defences on the Mesopotamian *Limes* (*Geogr. J.* 92 (1938) 62–66; 95 (1940) 428–438) offered opportunities to gain some closer acquaintance with the ground which had witnessed Alexander's operations in his final campaign against Darius. In the detailed report on my survey of Rome's easternmost *Limes* in 'Iraq and Transjordan, I have discussed the results of my observations. But that report, completed since 1941 with all needful maps and other illustrations, must under the conditions prevailing necessarily await publication for some time. This consideration provides a special reason for recording my observations on the topography of Alexander's campaign on the Middle Tigris separately. I am encouraged to do it since my friend Dr. W. Tarn from his unequalled acquaintance with the literature on Hellenic enterprise in the East assures me that this particular phase in Alexander's exploits has not, so far as he knows, received recent treatment.

All the classical accounts agree in stating that after Alexander had crossed the Euphrates on bridges thrown over the river at Thapsacus he rapidly marched on towards the Tigris and passed his army across it by fording. There is agreement also that though the passage was left unopposed by the Persians it was effected only with much difficulty owing to the depth and swiftness of the river.[1] No information is given by any of Alexander's historians as to the exact ford used. It has often been assumed since Ritter's work and, perhaps, by others also before,[2] that this crossing, the difficulties of

[1] See Arrian, 'Anabasis,' III, vii, 5; Curtius, 'Historiae,' IV, ix, 15 ff.; Diodorus, 'Bibliotheca,' XVII, lv, 2 ff.

[2] See Carl Ritter, 'Die Erdkunde,' vol. X (1844) 25; also Herzfeld, 'Archaeologische Reise,' vol. 1, 145 ff.

which both Curtius and Diodorus describe at some length, took place at Jazīrat-ibn-Omar, usually identified, though, perhaps, without adequate reason, with the Roman stronghold of Bezabde or Sapha. But there is no evidence supporting this, and a statement of Arrian, who is always more useful than other classical writers as regards the topography of Alexander's operations, distinctly militates against it. We are told by him that "on leaving the Tigris, Alexander passed through the country of Atyria (Assyria) with the Gordyaean mountains on his left and the Tigris on his right." Farther on we learn that on the fourth day after the crossing "the Macedonian scouts first sighted the enemy cavalry over the plain." When the Persian horsemen had



been put to flight and some captured it was learned from these "that Darius was not far off with a large army." [1] Arrian also records that "on receiving this information from the captured Persian scouts, Alexander stopped where he had received it, for four days; he rested his army after their march and strengthened his camp by a ditch and palisades" (Arrian, 'Anabasis,' III, ix, 1).

As regards the place to which the four days' march had brought Alexander's army we are fortunately helped by Curtius. He does not mention the time taken by the troops to reach it; but he definitely tells us that Alexander, on

[1] Arrian, 'Anabasis,' III, vii, 7; viii, 1 ff. Here and elsewhere passages are as translated by E. I. Robson in The Loeb Classical Library edition.

receiving information about Darius' army being within 150 stadia or about 19 miles, halted his troops and encamped for four days.[1] Reckoning this distance from the position where, as we shall presently see, the site of Gaugamela and its battlefield can be placed with certainty, we must assume that Alexander halted his army on the fourth day of its march in the vicinity of Nineveh, opposite to Mosul. From a variety of topographical and other indications it may be safely concluded that a halt at the site of this ancient capital, commanding important roads in different directions, must have offered distinct advantages to Alexander's army.

The accompanying sketch-map shows that the ford used for Alexander's crossing of the Tigris must be looked for considerably lower down the river than at Jazīrat-ibn-Omar, for the distance between the latter place and the site of Nineveh by the most direct route is fully 100 miles and the marching distance, taking into account road windings due to deep-cut drainage beds descending from the outer Kurdistān hills, must be a good deal more. In addition the considerable Khābūr river presents a serious obstacle. It is obvious that, starting after a difficult crossing, the Macedonian army, encumbered as it was with a heavy baggage train, could not have arrived from Jazīrat-ibn-Omar on the fourth day where Darius' mounted scouts were sighted and encountered in the plain, *i.e.* east of Nineveh. How heavy that train of the army must have been is shown by Curtius' statement that Alexander's force depended on supplies carried along with it, owing to the devastation of the country beyond the Tigris by Mazaeus, the commander of Darius' advance guard. Moreover the captive harem of Darius, treated with all royal honour, was being brought along with the army. Even if Alexander's crossing were assumed to have taken place at Faish Khābūr, a ford about 23 miles lower down, the distance to Nineveh would still have been too great to be covered by the four marches of Arrian's account.

Below Faish Khābūr only two places can come into consideration for fording with a large force after the floods of spring and summer have subsided. They are near the fairly large villages of Abū Dhāhir and Abū Wajnam. At both places easy saddles in the low but rugged chain of hills stretching along the right bank provide convenient approach to the river from the open valley plain which extends from Nisibis south-eastward. I have shown elsewhere that this broad corridor has always served as a natural route for invasion of north-western Mesopotamia (*Geogr. J.* 92 (1938) 65). The approximate road distances to Nineveh, about 69 miles from Abū Dhāhir and 57 from near Abū Wajnam are such as might well be covered in the course of four marches even by a heavily encumbered army.

Several indications point to the second of these as the likely position of Alexander's crossing. East of Abū Wajnam, which extensive remains of ruined structures mark as old, there is a gently sloping saddle down to a wide loop of the Tigris. There a ford leads across to a flat tongue of alluvial ground on the left bank. While distant from libraries I must confine myself to two references to the use of this ford gathered from the great storehouse of Ritter. It is near Abū Wajnam that Dupré, travelling from Nusaybin (anc.

[1] Curtius, 'Historiae,' IV, x, 15. The rough equation in miles is based on the assumption that the Attic stade is meant.

Nisibis) towards Mosul in October, 1808, forded the river on horseback.[1] Again, in the account given of Sultān Murād IV's march of conquest upon Baghdād [2] the Turkish army is said to have crossed the Tigris to the left bank after six days' march from Nusaybin at a point which lay at a distance of ten hours' journey above Eski Mosul. These distances agree closely with the crossing near Abū Wajnam.[2]

For the use of this ford in ancient times we have archaeological evidence. Guided first by observation from the air, I was able to trace in its vicinity the remains of two Roman *castella* which could only have served for watching the approach to this river crossing. One of them occupies a position on the left bank of the Tigris overlooking the ford which leads from the side of Abū Wajnam across a large loop of the river to the village of Qabaq. The other *castellum* is found some 6 miles farther north-east at Gir Bismār, where the route from the ford joins the present high road towards Nineveh. It is likely that these Roman *castella* date from the short-lived extension of Roman control to Adiabene under Trajan and the preceding crossing of the Tigris by Trajan's army.[3] Our information on Trajan's operations in this direction is very scanty, but one may suggest that the placing of these *castella* had something to do with a surviving tradition of Alexander on his invasion having crossed the Tigris here. There are some indications that Trajan in his Mesopotamian campaign was influenced by recollections of Alexander's more successful and lasting conquest, and that to some extent he endeavoured to emulate it (Guey, 'Essai sur la guerre parthique de Trajan ').

However this may be, Alexander's line of advance from the fording place to meet Darius did not lie along the greatly winding course of the Tigris but by the direct route leading, like the present high-road, along the foot of the outermost Kurdish hill chain to Nineveh. Arrian clearly indicates this where he makes Alexander pass between "the Gordyaean mountains on his left and the Tigris on his right."

[1] See Ritter, 'Erdkunde,' vol. xi, 428 ff., quoting Dupré, 'Voyages,' vol. 1, 114. The mention of Telmus, *i.e.* present Tell Mūs, on the way followed by Dupré from the caravan route to the ford, makes it certain that by the ruined village he passed before descending to the river, Abū Wajnam is meant.

[2] See Ritter, 'Erdkunde,' vol. xi, 153. Whether the ford of which Kinneir, 'Journey through Asia Minor,' p. 457, as quoted by Ritter, had heard in the vicinity of Eski Mosul as the only one passable in the summer, is the one at Abū Wajnam, is uncertain.

[3] For a succinct account of the information to be gathered from Dion Cassius (LXVIII, 27–28) about the Roman crossing of the Tigris on Trajan's campaign, in the winter of 115–116, see Guey, 'Essai sur la guerre parthique de Trajan' (Bibliothèque d'Istros, 1937). The passage of the Tigris valiantly contested by the Cardukoi, *i.e.* the Kurds, of Adiabene is said to have lain *κατὰ τὸ καρδύηνον ὄρος*, *i.e.* below the Kurdistan foothills.

In order to facilitate the crossing Trajan had small boats constructed at Nisibis with timber from the forests of Mygdonia and transported on carts to the bank of the Tigris. The distance from Nisibis to the Tigris ford and ferry near Abū Wajnam is somewhat greater than to the crossing-place at Jazīrat-ibn-Omar. But the transport of boats over the flat valley plain of the corridor stretching all the way from Nisibis down to Abū Wajnam would have been far easier than along the stony foothills of Mons Masius to be followed on the way from Nisibis to Jazīrat-ibn-Omar. I regret that neither the text of Dion Cassius nor Longden, "Notes on the Parthian campaigns of Trajan," *J. Roy. Soc.* 21 (1931) 13, note 5, quoted by Guey, is at present accessible to me.

Having followed the Macedonian army's march so far, we may now question the correct location of the great battle which played so decisive a part in shaping the relations between the classical West and the Middle East. There was doubt already in ancient times on this point as is shown by the critical remarks with which Arrian judiciously treats "the universal tradition . . . that the last battle with Darius . . . took place at Arbēla." "But most historians state that Arbēla was six hundred stades away from the place where Darius and Alexander fought their last battle: those who make the distance least, put it at five hundred stades. But Ptolemaeus and Aristobulus state that the battle took place at Gaugamela by the river Bumōdus. Gaugamela, moreover, was not a city, but a large village; it was not an important place, and the name has rather an awkward sound; and thus, as I opine, Arbēla, being a city, carried off the glory of this great battle." [1]

Neither at the time of my visits to this ground nor since have I been in a position to collect and consider the various opinions which scholars have expressed before as to the exact position of the battlefield in the light of such cartographical information as was available to them at the time. But when on 26 November 1938 I was on my way from Mosul to Erbil, I closely examined the area which could come into consideration with the accurate topographical evidence from the $\frac{1}{2}$-inch-scale map sheets Nos. 137.P.SW. and 137.P.SE. of the 'Iraq Survey. The observations then made, confirmed on my subsequent passage over this ground a year later, have convinced me that, by comparing significant topographical features of the ground with such clear indications as are given by the classical texts, the battlefield can be definitely determined.

The essential evidence is supplied by Arrian, where he tells us: "With this army Darius had encamped at Gaugamela by the river Bumōdus, about six hundred stadia from the city Arbēla, in a position level on all sides; for what few uneven parts for cavalry there had been the Persians had mostly made convenient both for chariot driving and for cavalry to ride over" (Arrian, III, viii, 7). This unequivocal statement as to the battle having taken place near the river Bumōdus is all the more important as it is based on the authority of Ptolemaeus and Aristobulus, who both shared Alexander's campaign in prominent positions.[2] Arrian in his detailed account of the battle does not mention the Bumōdus (or Bumēlus) again. But as he tells us that Alexander when pursuing Darius on his flight crossed the river Lycus before reaching Arbēla next day, it is certain that by the Bumōdus must be meant a river to

[1] Arrian, VI, xi, 4 ff.; Robson, whose translation is here quoted, puts the river name as Bumōdus in agreement with Arrian's text, III, viii, 7, but points out that the text has *Βουμήλῳ*; Curtius, IV, ix, 10, has also *Bumelo*.

[2] See Arrian's statement, VI, xi, 5. It must be specially noted that this passage, as it stands, does not imply the authority of Ptolemaeus and Aristobulus for the distance between the place of battle and Arbēla. That estimate, whether 600 stades, as attributed in that passage to "most historians," or 500 stades given as that of "those who make the distance least," is impossible. The distance between Gaugamela and Arbēla, according to the positions indicated by Ptolemy, 'Geographia,' VI, i, 5, is either 200 or 320 stades, but the coordinate readings are uncertain. The former distance would approximately agree with the distance from Erbil to the river Khāzir. But no reliance can be placed on Ptolemy's mapping. For the supposed distance derived from the latter, see Herzfeld, 'Archaeologische Reise,' i, 144, note.

the west of the Great Zab, the identity of which with the Lycus cannot be doubted. The only river which any route from the vicinity of Mosul can cross before reaching the Great Zab is the Khāzir, a tributary of the Zab but far smaller and fordable during most of the year. The direct high-road, connecting Mosul with Erbil and used to the present day, leads across the Khāzir at a distance of about 5 miles in a straight line to the north-west of Kelek. This, as its very name shows, is the traditional crossing-place of the Great Zab on the high-road.

We are told by Curtius that Darius, after depositing most of his stores at the town of Arbēla, had the Lycus river bridged and in the course of five days passed his army across it. Proceeding hence for close on 80 stades he encamped at another river called Bumēlo: "It was ground suitable for deploying the forces, a uniform great plain. No trunks or brushwood cover the soil, and an open view is offered to the eyes even to distant objects, and wherever ground rose higher he (Darius) ordered the whole space to be levelled and extended" (Curtius, IV, ix, 9 ff.). From Curtius' elaborate and highly rhetorical account of the great contest no definite topographical indications can be gathered. In his description of the Persians' flight after the fate of the battle was decided, no mention is made again of the Bumēlo river. But we are told of the disaster which attended their retreat to Arbēla when the bridge across the Lycus could no longer withstand the onrush of the fugitive host (Curtius, IV, xvi, 16 ff.). Curtius' statement that Darius on his flight after the battle reached Arbēla close on midnight is credible and of special interest. It proves how greatly exaggerated was the general belief which, as Arrian records with just doubt, put the battlefield at 600 or 500 stades (roughly 75 or 62½ miles, respectively) away from Arbēla. The more succinct account given by Diodorus of the battle and the moves of the armies preceding it furnish no topographical indications. But it mentions that Darius was induced to lead his forces towards Ninos or Nineveh by the advantage which the open plain of that region could offer for the disposition and full use of his huge host (Diodorus, XVII, liii, 4).

From this rapid review of the essential classical notices bearing on the battlefield we may now turn to the evidence of the ground. From Erbil, the undisputed site of Arbēla of which it perpetuates the name, towards Nineveh by the line which the high-road must have followed in ancient times as it does now, the ground slopes gently flanked on the south by the hill chain of the Demir-dāgh. After about 23 miles the Great Zab is reached where now a long iron bridge leads across to the village of Kelek. Beyond the Great Zab there stretches much broken hilly ground where the battle could not possibly have been fought. After crossing this ground for 6 miles, the high-road takes us to a point on the Khāzir river, the Bumōdus, flowing in a winding bed from north to south where the bed is wide and easily fordable, except at times of heavy rain floods.

Beyond this there lies open ground giving access after 2 miles to a remarkably level plain steadily widening towards the north-west. As the sketch-map shows, this plain extends for fully 8 miles from south-east to north-west with a maximum width of about 7 miles. On the south it is flanked by low flat-topped hills trending towards the Tigris and rising to heights of a little over

1000 feet above sea-level. On the north the wide plain is overlooked by the steep Jabal 'Aīn-as-Satrah culminating in a rugged crest at a height of 2200 feet. Near the large village of Bartallah, a flourishing place of Catholic Jacobites, the foot of the Jabal 'Ain-as-Satrah is approached by a low outlier of the southern hill chain stretching to the north-east. Here the level plain which concerns us may be considered to end.

On a line running from Bartallah due south as far as the village of Qaraqosh the ground is very flat. When passing across it with a motor car I noticed only one insignificant shallow drainage channel. The watershed which the map indicates between a wadi farther west draining into the Tigris and a small brook fed by springs near the large village of Keramlais was quite imperceptible to the eye. Only at one point on this fertile well-cultivated plain is there a marked elevation. It is a small but in its isolation very conspicuous mound, unmistakably artificial and probably of prehistoric origin, some 300 yards to the west of the nearest dwellings of Keramlais. It rises steeply to some 70 feet above the level ground and measures about 120 feet across its flat top. Into its foot has been built a small and apparently old church, one of the three which serve the spiritual needs of the five hundred odd Jacobite households of Keramlais. The mound would have served as an excellent observation post to watch the course of the fighting had Darius chosen, as his ancestor Xerxes did at Salamis, to be a spectator of the battle instead of sharing the fray. It was easy to see, both from the top of the mound and on the ground below, how admirably the flat plain fits the description given by both Arrian and Curtius of the wide field of battle which the Persians had taken care to choose and prepare for easy movement of both cavalry and chariots. The great advantage that the battle was fought in the month of October (331 B.C.) should be remembered (Arrian, III, xv, 7). This was before the autumn rains had started and when after the long dry season of the Assyrian plains the surface even of irrigated ground must have been very firm and hard.

This is not the occasion to discuss the disposition of the forces on both sides and the development of the action. Arrian's account, written with the author's military knowledge, presents it very clearly in its successive phases. Arrian tells us that when Alexander after the four days' halt, close to Nineveh as we must assume, had brought up his forces in battle array about dawn to within 60 stades of the Persian position, the two armies "did not as yet sight one another; for there were hillocks (*γήλοφοι*) intervening in front of both (*ἐπίπροσθεν*). When Alexander was about 30 stades away and his army was already descending these hillocks sighting the barbarians, he drew up there his phalanx." After taking council with his generals Alexander on Parmenio's advice encamped and then, taking with him the light-armed troops and territorial cavalry, rode all round surveying the ground which was to be the battlefield (Arrian, III, ix, 2 ff.). After this reconnaissance he let his army take their meal and rest. Deciding against a night attack as recommended by Parmenio, he resolved upon action on the morrow (Arrian, III, x, 1 ff.). On the Persian side we are told that "Darius and his army remained during the night marshalled in the order which they had drawn up at first; for they had no proper entrenched camp" (Arrian, III, xi, 1).

If we follow the direct line from the left bank of the Tigris below Nineveh towards the flat plain above described we can see that a march to within 60 stades or 7½ miles of the Persian position, assuming this to be aligned near the middle of the plain about Keramlais, would have carried Alexander's force to a fold of lower ground north of that outlier of the hill chain which stretches, as shown by the 100-foot contour of the ½-inch map, from the left bank of the Tigris towards the northern extremity cf. the plain near the village of Bartallah. From this ground the Persian array would certainly not be visible. But an onward march of 30 stades or 3¾ miles across that low outlier would have brought Alexander's troops to its southern foot and thus approximately to the position marked by the village of Minārah Shebek on the north-western edge of the plain.

We have to take into account the great size of Darius' army, comprising contingents from the most distant parts of the Empire and estimated in Arrian's record at 40,000 horse and 1,000,000 foot. It seems clear that a host so great, even allowing for exaggeration in numbers, could be drawn up in the array which Arrian describes on the authority of Aristobulus from captured Persian records only where the plain was sufficiently wide. Such a width, in the westward direction from which the Macedonian attack was bound to come, is shown by the plain first on a line running approximately from near Qaraqosh in the south past Keramlais to the foot of the Jabal 'Aīn-as-Satrah.

The latter provided safe protection for the Persian army's right flank against any mounted attack. Similar though less effective flanking defence on the left flank might have been sought on the lower hills stretching along the southern edge of the plain past Qaraqosh. The high mound close to Keramlais with its commanding prospect was not likely to be left outside the line assigned to the Persian army when arrayed for battle. The natural flanking protection afforded by hills may have had something to do with the Persians having had no proper entrenched camp. This fact is emphasized by Arrian as having "more than anything else hampered the fortunes of the Persians at this crisis," as it implied for them a long stand under arms preceding the day of battle (Arrian, III, xi, 1 ff.).

In Arrian's account of the actual battle, we find some indication of the ground in what we are told of the initial operation on the Macedonian right wing. This Alexander himself commanded, having with him the royal squadron. He is said to have "led off his men rather in the direction of his right, on which the Persians moved accordingly, their left far outflanking the Greeks. Already the Scythian cavalry, riding parallel with the Greeks, found touch with the troops posted in front of Alexander's main body; but Alexander still continued steadily his march towards his right, and was nearly clear of the ground which had been trampled level by the Persians," until Darius became "afraid lest—if the Macedonians reached the uneven ground—his chariots would be of no service" (Arrian, III, xiii, 1 ff.).

There is no need for us to follow the manoeuvres by which Darius attempted to insure that "the Greeks might not prolong their wing any further," nor the subsequent course of the fighting. This definite reference to the uneven ground at which Alexander with his right wing aimed by the

steady move to the right is fully understood if we look at the map. It shows clearly that by moving his wing to the right Alexander was bound to reach the higher ground where it skirts the southern edge of the plain marked by the hill contours beyond Qaraqosh. There the artificial levelling could no longer serve the Persians for the use of their scythe-armed chariots.

Curtius mentions a hill on which Mazaeus, sent ahead by Darius on a reconnaissance, had placed himself and which the Macedonians subsequently occupied. This agrees with the ground as described above (Curtius, IV, xii, 18 ff.). Similarly we may, perhaps, recognize some reference to the height of the Jabal 'Aīn-as-Satrah in the passage which rhetorically describes how Alexander lying sleepless during the night preceding the battle pondered whether he ought to attack the Persian right *e iugo montis* or charge the enemy straight in front (Curtius, IV, xiii, 16).

What we learn from Alexander's historians of the pursuit of Darius and his vanquished hosts which brought the great conqueror to Arbēla and secured to him all the royal treasures there deposited, does not help us to determine the exact ground where the hard-won victory was achieved which gave Alexander domination over the vast Achaemenian empire and finally opened the way for Hellenistic penetration into Asia. The estimate of distance from the battlefield to Arbēla as 600 or 500 stades, as we have seen, is certainly much exaggerated.[1] The distance between Arbēla, or Erbil, and the Bumōdus or Khāzir river where Darius' camp is stated to have stood, is in reality less than 30 miles along the present high-road. This, considering the topography, must always have been the line followed by traffic.

Whatever may be the explanation for this error in recording the distance, it is significant that Arrian quotes it in the same place where he records his just dissent from the "universal tradition which has it that the last battle with Darius took place at Arbēla." We have equal cause to be grateful also for Arrian's critical judgement where he quotes the authority of Ptolemaeus and Aristobulus for the definite statement "that the battle took place at Gaugamela by the river Bumōdus" and rightly explains the reason for this instead of the prevailing but erroneous location.

To Arbēla that fame has clung ever since. The huge mound, probably of prehistoric origin, on which the town of Erbil stands, still rises, conspicuous from great distance, as if it were a monument to commemorate the great event. But Gaugamela, too, has left its mark on the ground, be it only by its name, to confirm the true site. Long after the above discussed topographical indications had led me to recognize in the plain near Keramlais the site where the battle was fought, I found in a brief note of Professor Herzfeld the name of Tel Gōmel identified with that of Gaugamela (Sarre-Herzfeld, 'Archaeologische Reise,' I, p. 144). Unaware of this identification, convincing enough on philological grounds, I did not at the time visit the locality. Nor is its name to be found in the 'Iraq Survey's map. But I have since been kindly informed by Mr. Taylor, Chief Engineer of the 'Iraq Petroleum Company,

[1] Arrian, VI, xi, 5. It is assumed that Attic stades are meant. Even if Bematists' stades instead of Attic stades were intended in Arrian's text, the distance estimate, at the usual rough reckoning of 1 : ¾, would be too great.

Kirkuk, that the War Office Map, 1 : 125,000, No. J 38/T, marks Tel Gōmel about 6 miles due north of the confluence of the Khāzir with the Great Zab. This takes us to a point on the Khāzir river, just 6 miles south-east of Keramlais and on the direct track leading to the latter place from Kelek. Gaugamela by the Bumōdus was the place where Darius' army was encamped (Arrian, III, viii, 7). Professor Herzfeld's identification of the name of Tel Gōmel, derived from Gaugamela, can hence be accepted as confirming the battlefield we arrived at on purely topographical grounds.

The observations set forth may be held to illustrate once again the words of a great strategist and student of history: "The locality is the surviving portion of an event that has long passed by. . . . It often restores to clearness the picture which history has preserved in half-effaced outlines" (Helmuth von Moltke).

Since the chapter of the report on my *Limes* explorations was written from which the above pages are extracted, information kindly given me by Dr. W. Tarn in a letter dated 27 December 1940 has brought to my notice that Droysen, guided mainly by a sketch-map by Černik (*Petermann's Mitt.* No. 45) of the caravan road from Erbil to Mosul, had in the second edition of his great work, 'Geschichte des Hellenismus' (1877), quite rightly placed the battlefield near the village of Keramlais (or Keremlis as he calls it); and that in this other writers have since followed that great scholar. Unable to gain access in India either to Droysen's text or to Černik's sketch-map, I am left in doubt as to what extent the imperfect topographical data available at the time may account for Droysen's suggestion that Keremlis is Gaugamela where Darius' army was encamped, and the small brook which flows near the village is the river Bumōdus. In view of the greater knowledge of the ground now secured this identification can no longer recommend itself.

PHYSIOGRAPHICAL NOTES FROM LAKELAND

THOMAS HAY

High-level erratics and boulder trains

THE distribution by glacial action of some of the more distinctive rocks has been mentioned by many writers. Perhaps the men of an older generation to whom we owe most in this respect are J. G. Goodchild and Clifton Ward. Most of the striking examples which have been recorded are on lower ground and not many cases occur at the highest elevations. However Ward gives a few which are all easily found. He mentions a train of erratics crossing Birks, the north-east continuation of St. Sunday, between 1750 and 2000 feet, oriented as if the ice was moving down the middle reach of Ullswater. The highest example in his 'Geology of the northern part of the English Lake District' is south of Raise (Helvellyn range) 2700 feet; he also calls attention to the difficulty of being sure boulders are erratics owing to the uniform appearance of the Borrowdale rocks.

Some of the highest erratics that I have found are several between 2500 and 2750 feet and some on Crinkle Crags about 2800 feet. Among the trains of boulders there are: a number of grey-blue tuff boulders lying on andesite on the shoulder of Gavel Pike (St. Sunday) 1500–2100 feet; Sheffield Pike 2230 feet; and the most interesting of all, a train crossing the north-east projection of High Stile at about 2610 feet. The top of the mountain is a *felsenmeer* or block-spread, and from the appearance of many of the blocks I felt confident that they were erratics though it was impossible to prove it until I found this remarkable train. The north-east spur of High Stile projects between the two fine corries, Burtness Combe on the south-east and Bleaberry Tarn Combe on the north-west. On the very edge of the spur and overlooking Burtness Combe there is a striking cliff of pin-head tuff which weathers light grey. Boulders of this form a train right across the spur from the edge of Burtness Combe to the opposite edge of Bleaberry Tarn Combe. There are over fifty of these grey erratics on a narrow corridor not more than 30 yards wide running for 50 yards across the top of the spur, and a great number form a mass at the top of the cliff. The direction of carry is west-north-west nearly parallel to the upper course of the river Liza, from Honister Crag to High Stile top, involving a movement of the ice over a mountain top of 2640 feet. It is very fortunate when an identifiable rock proves movement by ice. In this case these boulders are all short-distance erratics; they make one more certain that many boulders dispersed on high ground are really erratics.

Felsenmeere in Lakeland

It is a matter of regret that the foreign word *felsenmeer* is used when an English term such as block-spread would have described the phenomenon just as well. Högbom uses *Blockfeld* and *Blockmeer* as well as *Felsenmeer*. Perhaps the most famous and distinctive of these local boulder collections is that on the top of Scafell Pikes. References to these block-spreads are rare,

but Marr mentions them in his 'Geology of the Lake District,' and recall that Clifton Ward calls attention to "a certain blocky structure common to several of the mountain tops." Ward regarded them as due to weathering with earthquakes as a subsidiary cause. Marr does not think earthquake action necessary and attributes them to "frost assisted by other agents operating upon massive rocks with well-formed joints"; he then quotes R. A. Daly that these boulder tracts are evidence not only of rapid frost attack but also of more "effective attack by agents other than frost." It is interesting that both these writers mention other forces than frost but do not specify what they are.

The two divides bounding Ennerdale on the north and on the south give much information about these block-spreads. To the north, Starling Dod composed of Skiddaw slate, is littered with erratics of granophyre, some of them quite small and insignificant. Proceeding eastwards with very little change of altitude there is another small summit of Skiddaw slate, again with granophyre erratics; a granophyre block-spread lying in a shallow boggy hollow; Red Pike, metamorphosed Skiddaw slate, again with granophyre erratics; a slight dip, and then the top of High Stile where there is the notable block-spread previously described. The whole of this divide round about 2000 feet, has had the same treatment glacially and sub-aerially *felsenmeere* are found only on the granophyre and Borrowdale rocks, both rocks with large well-formed joints as Marr pointed out.

On the divide south of Ennerdale the evidence is similar. A part of the top of Pillar shows a small collection of diminutive boulders of Borrowdale rock. Going westwards by Windy Gap: Scoatfell, Haycock and Little Gowder Crag provide examples of Borrowdale block-spreads. When granophyre comes in, the divide becomes more subdued, much of the summit line leading round past Iron Crag towards Crag fell consisting of granophyre block-spreads with erratics of granophyre as well as intruders of Borrowdale rock. The ground described on the south side of the Ennerdale valley varies from 2900 to slightly below 2000 feet. Again the block-spreads occur only where there is a massive rock with big well-formed joints, and again there are erratics amongst the boulders.

Marr in his 'Geology of the Lake District' writes: "Notwithstanding the general disturbance of equilibrium by glacial action tracts were left here and there where slopes were too slight to permit appreciable transport of weathered material, and this would remain upon the rocks from which it was derived. Gentle slopes of this character occur on many ridge-summits." This conclusion is entirely supported by the evidence already given and later examples confirm the belief that these *felsenmeere*, though partly fro features, have in many cases been affected by glacial action. The erratics that can be detected are lying at the general block level. These collections are in part contemporary with the glacial epoch and consequently cannot be used as evidence of the amount of sub-aerial weathering since that period.

As to the other forces that have contributed to their formation mentioned by Marr and Daly, it seems that a good deal of movement would be caused by the slow small adjustments from sapping and mining by water percolating on and near the surface. On Nethermost Pike the general horizontality of the

Blockspread on top of Hartside, Great Dod left distance, Skiddaw background

2. Erratic above Linkindale, Ullswater in distance

3. Stone flat on Hartside, Blencathra left background

4. Stone flat on Hartside, Ullswater 2000 feet below, top left

5. Weathering of live points of rock on ridge leading to Low Man

spread shows the effect that can be produced by small localized solifluction movements. The blocks tend to level themselves out in a flat spread much as stones do on a shore. In the former case the weight of the block is taken off by the mushy ground mass after thaw and in the latter case by the buoyancy of the water.

To sum up, the main action in the development of these block-spreads has been vigorous frost working on massive rocks with well-marked joints. Many of the spreads show ice action in the movement of some of the blocks. Lastly there are often small solifluction movements as well as small adjustments through sapping by percolating water.

Two cases of summit weathering

Stone flats.—Plate 4 shows a stone flat developing near the top of Hartside at about 2400 feet. The camera is tilted slightly downwards and Ullswater just shows at the top left-hand corner. The patch of stones is practically level but is sloping a little away from the observer. The rock in the left-hand corner, the piece at the right-hand upper corner, and also the bigger part away to the left are live rock. The stones on the surface, formed by frost action, are wonderfully consistent in size. There is only one layer of these bigger stones on top measuring $5 \times 3 \times 2$ inches as an average. Below them comes a layer of smaller fragments, and below this fine black soil. The latter is continuous beneath the layer of stones but not of uniform depth; two measurements gave 4 inches, and another between 2 and 3 inches. Below there is live rock.

On the far side of the rock flat there is a little stream of surface stones working their way down the live rock edge (Plate 3). The solifluction processes move a small number down the slight slope from time to time and these fall down the small cliff at the margin. In time the remaining live rock will disappear under these forces and there will be a small terrace of loose material. When these stones are sufficiently reduced the patch will become covered with grass. Any one visiting it during a thaw after a hard frost would find the whole surface spongy with the layer of stones resting on a black slush. The normal order from soil to sub-soil to rock has been changed, we have top stones, then soil, and then live rock.

Weathering of live points of rock.—Plate 5 is taken on the slope of the north ridge leading up to Low Man which is on the main Helvellyn backbone but separated from the summit by a slight dip. The camera was tilted upwards. No stone stripes actually show in the picture, but they occur freely on this slope. There are two excrescences on the sky-line, the only live rock in the picture, the left-hand one rising above the general level in a flattened bulge and the right-hand one showing three separate projections. They are surrounded by a mantle of loose material. The projecting live rock will be destroyed in course of time and then the cover of slowly moving debris will be complete, its matter being renewed by further disintegration from the rock surface below. The solifluction motion of the loose material, slow though it is, hastens disintegration as it leaves the rock exposed to further attacks by frost. The combination of these processes is tending to produce greater uniformity in outline and so to increase the appearance of subdued

relief which we find all along the west side of the Helvellyn range below the summit line.

Solifluction phenomena on the fells

In a previous paper in the *Journal* (90 (1937) 426) a fairly full description of some surface phenomena was given in which the influence of solifluction was shown to have a considerable part. Patches of mountain on suitable slopes show the presence of stone stripes, garlands, terraces, and gliding blocks, and there are close at hand other patches where vegetation has once more gained its hold and is now masking old examples of these features.

The stone stripes are so well known that they hardly need description. On our fells they usually consist of parallel lines of stones running down the main slope, separated from each other by wider strips consisting of finer material. The distance between two coarse stripes varies from 13 to 17 inches. Terraces vary in size; they do not need the complete removal of the vegetation and so are commoner than the stripes. Garlands are waves of loose matter descending the slope under solifluction; they therefore lie normally along a contour line provided all the contributing conditions are similar in each direction along that line. The gliding block has a wider range than any of these other phenomena; it is found at lower levels and descends as low as 1500 feet.

Generally gliding blocks, stripes, and garlands may occur where the slope is about 1 in 7; terraces on any flat or gently rounded surface. None of them form on slopes so steep that the descent of waste material becomes violent. To sum up, these phenomena occur on these fells where slope and material are suitable for the solifluction processes and where the elevation is sufficient for frost action. Nowhere are they on a large scale. They are small modifications of the surface, but when one has learnt to distinguish them they are there on practically every fell above 2400 feet unless the surface is a block-spread. They are small-scale examples of what is taking place on a great scale in Arctic regions.

The influences which have contributed to mould the rounded and subdued forms of summit land have been much discussed. In 1892 Davis thought that the explanation of the convexity of hill-tops examined by him lay in creep. G. K. Gilbert, in his paper in the *Journal of Geology* for 1909 on the "Convexity of hill-tops," expressed his belief that the normal product of degradation by creep is a profile convex outwards. Quite recently, in the *Journal for Geomorphology* for 1939, "Sur les gradins de Piedmont," Baulig writes, "La convexité traduit l'influence prépondérante du creep et du ruissellement diffus; la concavité celle du ruisellement concentré en filets." It seems to me that in these rounded and subdued tops of our fells where these solifluction results are in evidence we have this same influence at work. It has been continuously active ever since the fell tops were clear of ice and snow. It was probably a stronger influence in the past than it is now; therefore without claiming that this influence created these subdued areas it is quite justifiable to claim that it has had a considerable effect in moulding the surface as we see it to-day.

High-level local drift

Some deposits composed of local materials occur at high altitudes. They are without structure of any kind and are for the most part made of rock fragments, gravel, and soil from the immediate neighbourhood. They do not appear to have been deposited from water. Indeed they have all the characteristics of a material produced by frost on or near their present site. The surface of the deposit is continuous with the general slope of the fell upwards to the rounded crest and downwards towards the valley slopes where a true boulder-clay is found. These deposits are not increasing at the present time but are suffering considerable diminution, being cut into by gullies developed erratically as the surface runners vary. Such little valleys may be cut by a very heavy rain and then later clothed with vegetation. The result is that the nature of these deposits is rarely seen except where recent erosion has occurred and where a rare and more permanent gully is found. Such a deposit occupies the head of Cumberland Deepdale lying east of Watson's Dod. Here it is 6 feet deep at an elevation of 2500 feet. From this description it will be realized that these deposits resemble head.

When I visited the Howgill fells to see a similar product fully described in a paper by Marr and Fearnsides in 1909 (*Quart. J. geol. Soc.*, 65, 587), it became evident that the deposits were of the same nature in the two places. The scale on which this drift is produced on the Howgill fells is far greater than any I have seen in Lakeland. Plate 6 shows that there is a considerable depth and that the gullying and ridging is on a large scale. Live rock is only to be found after some search. Doubtless additions are made to these deposits by the ordinary weathering processes but on the whole the mass is being reduced at a fairly rapid rate. The upper end of Great Swindale has a big mass of this deposit. Its left side, as one looks down the valley, faces to the north-east and has the greatest amount, while the opposite side facing the afternoon sun has a much feebler cover. This fact again supports the supposition that the drift is a nivation product formed during or after the glacial epoch when the top of these fells was not occupied by ice. The summit land of the Helvellyn Dods and the Howgill fells is characterized by a subdued relief. It is noticeable that the latter hills are of Silurian rock which is more fissile and responsive to frost attack than is the Borrowdale rock of central Lakeland. This may partly account for the greater development of the drift on Howgill fells, but an equally important consideration is the length of time during which the two places were exposed to the conditions which produced the drift.

"The mapping of head deposits," by H. G. Dines and others (*Geol. Mag.*, 77 (1940) 198), gives much information about the formation and characteristics of this material. None of this is contrary to the conclusion that the deposits at Deepdale Head and on the Howgill fells are further examples of head. The deposits indicate a long exposure of such areas to severe frost conditions at a time when they were not occupied by a complete ice covering. One would not expect such deposits on the areas around Scafell Pikes where the effects of strong glaciation are retained in a high degree.

It is considered that the uniformity of the surface and its continuous character are due to the adjustments effected by solifluction and the preservation of the deposit afterwards is largely due to protection by vegetation.

Moraines

Moraines are such indisputable evidence of ice action that they are always a source of interest. But they do not occur in our main valleys with anything like the frequency that might be expected. For example it has often been remarked that no terminal moraine can be found in the Ullswater valley. As a partial explanation of this one has to remember that in the mountain region the chief work was excavation and removal, and that when moraine matter was deposited it must often have been exposed to very destructive influences. There is evidence of this in the remainder knolls that are found in valleys like Grisedale and Eskdale. On the other hand moraines occur in most unexpected places. Sometimes they have something peculiar about their arrangement as for example at the head of the valley of the Liza, at the foot of Great Gable, where there is an assembly of moraine mounds which is striking in its extent. It lies above the Youth Hostel with its mounds like the waves of a little sea. Its hummocky surface reminds one of that even more striking collection in a side valley of Glen Torridon. At first sight there is no order in the arrangement, but looking closer one sees that the mounds do not lie symmetrically across the valley but swing across obliquely as if the final gathering ground had lain not at the middle point but rather at the side where the rampart of high land running round from Great Gable towards Kirk fell protected the lingering ice. This would make the final corrie glacier face nearly north, a favourable orientation for its preservation.

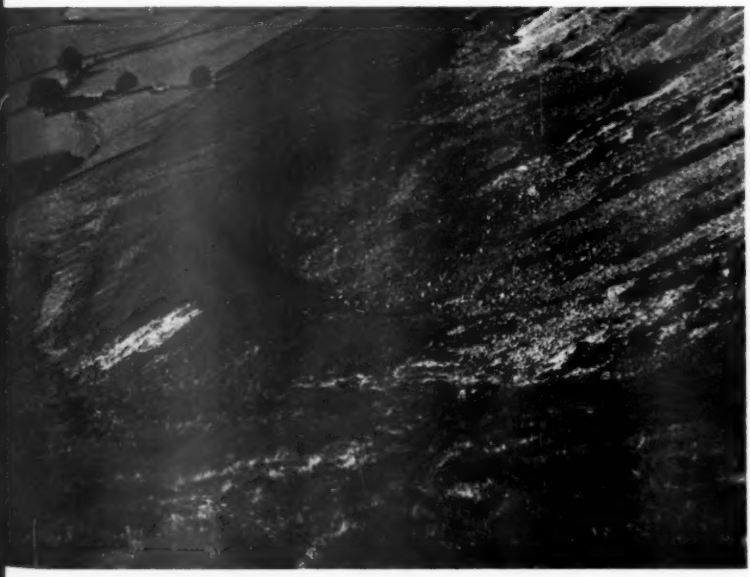
Another distinctly noticeable morainic arrangement is the beautiful curved deposit round the south-west foot of Herdus. This would not have been remarkable on the opposite side of the mountain. The mountain just reaches 2000 feet with a steep face running up on the right above the curved moraine shown on Plate 7. There is no corrie, yet a small glacier of cliff-ice has existed here possibly for only a short time. Most of the corries face some point between north and east, but not by any means always. The fine corrie of Keppel Cove with its excellent semi-circular moraine faces south-east and the series on Blencathra faces due south.

Rock fissures

In the *Geological Magazine* for 1873 Clifton Ward in an article on rock fissuring, mentions Helm Crag near Grasmere where "The Old Woman Cowering" and "The Lion and Lamb" are well-known features; also a rather different series on Kirk fell. He enumerates three explanations which might be given for these features: that they are strictly of the nature of slips, that is, the mass of the mountain or some part of it pressing outwards or towards the flanks; that they are caused by earthquake shocks; or that they are outward expressions of faults slowly taking place and that they represent greater disturbances or shifts at considerable depths. Ward finally inclines towards earthquake shocks.

In a large quarry in the microgranite at Threlkeld an artificial result similar to the natural fissuring on Helm Crag has been produced. There is a high perpendicular face measuring 200 feet running east and west. The top of the cliff is a level piece of ground. Where the modern wall running north and south on this flat top comes to an end at the brink of the precipice there

6. High-level local drift on Great Swindale Head, Howgill fells



7. Moraine at foot of Herdus, Ennerdale

8. Trench on east side of Helm Crag

9. Scree on Bowness Knott, jointing with overhang towards scree

are great cracks in the flat top owing to the lack of support from the north side.

The most striking crack is semi-circular. It encloses a patch which has dropped from 2 to 3 feet and is separated by a gap of sometimes 16 inches from the main mass. As so often happens in land-slipping the surface has a back tilt, in this case it slopes to the south. The second crack is 17 yards long, has the same considerable width in the widest part and runs out irregularly to the edge. The third crack is much less noticeable and only 9 inches wide. Its drop runs down from 1 foot to nothing. About this spot the whole edge is quite unstable. In this example of a huge experiment carried out by the quarrymen the cracks described are due to the removal of sustaining horizontal pressure by continued quarrying in the past.

The features at Helm Crag are on a much grander scale but they may be due to somewhat similar causes. Here several narrow but deep fissures occur across the top of the fell, and into these fragments of rock have fallen. These lines of weakness cross the top roughly from south to north but not quite parallel to the run of the mountain edge. There are gaping fissures in several places and also great holes. Generally the cracks run fairly straight but some are rather curved and one at least near the east edge is roughly semi-circular, bounding a great mass which seems to be moving east from the hill-top. There is a great hollow in the centre of the top lying on the line of one of the weak belts and looking like a huge rough cauldron. It is covered with angular boulders, as is much of the mountain top. One crack leads down at the north face of the crag into a great rock-walled gully. A big trench, marking the run of one of the lines of weakness, runs north and south along the east side of the mountain looking like a prehistoric fortification (Plate 8). It appears as if the formation of the crack was a slow gradual process enabling the descending rock debris from the main hill-top to partially fill up the depression while this slice of the mountain moves slowly to the east.

One major joint system dips steeply to the west and this leaves much rock overhanging the cracks as they develop. Therefore under weathering, fragments large and small are discharged into the cracks and over the surface. This effect of jointing combined with the effect of percolating water must be held largely responsible for the change involved. But there is probably a more important cause still, namely the oversteepening of the east side of the crag by glacial action. This has removed the supporting lateral pressure of the rock mass taken away by the ice, resulting in the changes described.

Similar phenomena can be found elsewhere in this area; a good example is to be seen at the head of Linkindale, the deeply excavated upper combe of Glencoin. Here again the oversteepening is very evident as a likely explanation. Though all rock fissures will not be due to one sole cause it seems highly probable that many of those found in this area are caused by glacial action in removing lateral pressure.

Ice-rounding and jointing

The action of ice upon the rock-head is variable in the extreme. The well-known *moutonnée* effect is not produced unless the rock offers a strong resistance to the pressure of the moving ice. Examination of many *roches*

moutonnées shows that there is often a certain arrangement of anti-stoss joints advantageous for resistance. If there is a *moutonnée* rock shaped out of a massive material with few joints and most of the master joints in some position verging on vertical, it may be represented as in the figure. The forces acting on A, besides its own weight when the superincumbent ice moves from left to right are: a pressure downwards from the ice which may be very great; pressures exerted by the surrounding portions of rock; and a horizontal pull in the direction of ice movement. But under the given conditions, motion of this block is impossible as it is locked into position by these forces and the joint arrangement. Thus its existence being guaranteed for some time it is possible for it to acquire the rounded form under the grinding of the ice loaded with abrasive material.

Where the main jointing lies nearly horizontal or in a direction more nearly approaching that of the ice movement then it becomes possible and easy for the ice to remove blocks of the rock by plucking. It is not uncommon to find under a cover of boulder clay the rock-head with its surface composed of irregular and sharp-angled planes of jointing. Blocks have been removed with such ease that the underlying rock has never kept an enduring surface sufficiently long to become rounded through abrasion. Such joint arrangements might be called examples of "cum-stoss" jointing.

The extra permanence bestowed upon a belt of rock by an arrangement of anti-stoss main joints may be sufficient to enable it to develop into a bar or *riegel* at the lip of a corrie or even in a valley.

Screes, fans, and slopes

Screes are accumulated where the rock has been left in cliff form after the glacial epoch. But the amount of the scree depends on the nature of the rock, and, above all, on the arrangement of the joints. When the latter give the rock an overhang towards the slope there is generally a large scree formed. A good example of such formations occurs on the south side of Bowness Knott (Whitehaven Memoir). Here the hardened Skiddaw slate takes on the characteristics of a Borrowdale rock. The slope of scree partly depends upon the average size of the fragments, being steeper as the fragments increase in size. This rule does not apply if the fragments are flaggy, as this tends to reduce the slope. Generally the scree slope is slightly over 30° to the horizon; a good scree on Glenridding Dod gave 35°. Others in the Ennerdale valley gave 35°, 30°, 31°, 34°, and 25°. The lower part of the scree will tend to rest at a slightly smaller angle to the horizon, despite the fact that some of the largest fragments are sometimes found there.

Fans or dry deltas are formed by intermittent stream action at the foot of gullies. Just as in ordinary delta formation, any point on the line of the main stream may, when a blockage occurs, become a source of distribution of the debris. Consequently if the stream digs itself a deeper incision in the upper part of a fan, that upper part on each side of the stream becomes more or

less stabilized and the active fan-head is located below that upper portion. In other words, the fan has developed terraces. An example of this occurs in a fan on the south side of High Stile. The upper more stabilized part has enabled the trees planted by the Forestry Commission to make a better show than those on the lower part of the fan. The surface inclination of these fans varies a good deal. The less water action there is, the greater will be the approach to the scree form. The finer the material the greater will be the approach of the main front slope to horizontality. Two measurements in the Ennerdale area, neither near the bottom nor the top of the fan, gave results of 15° and 16°.

In some cases, as along the cliff face on the west side of Ennerdale, the frontal slope of the live rock is nearly in the same straight line as the slope of the scree lying at its foot, the live rock being weathered back to such an extent that there is one continuous slope in profile. This may be regarded as the first stage of that long process during which the mountain acquires a more subdued form. But such a scree slope is often pierced here and there by live rock. As the scree with its slow spasmodic movements of adjustment moves past these projecting points, they become gradually reduced until a continuous scree covers a wide area as on the slopes bounding the south-east side of Wastwater. Movement takes place in these screes, but only rarely does one hear or see the motion. The Whitehaven Memoir of the Geological Survey records that "heavy concentrated rains or cloud-bursts of the spring and summer of 1927 caused visible movements of both covered and bare screes rarely witnessed in our upland districts."

The windward trend in deltas

In the *Journal* for 1937 (90, 426) it was stated that deltas showing a windward trend of the beck mouth were not uncommon in Lakeland. Since that time a further necessary condition has been noticed for the persistence of this feature, arising from the relationship of the point A, the stream head of the delta, with regard to the fluctuations of water-level in the lake.

In the Glenridding delta a new course has been recently established for the beck mouth through the influence of the law of unequal slopes. Soon after this a big flood occurred in which the lake-level rose above the point A with the consequence that this new course was completely blocked by stranded matter dumped by the loaded beck as soon as the lake water was reached. The result was the return of the beck course, when the lake fell, to the course occupied before its diversion. Thus it is seen that when a windward trend has been established, even though it occupies a privileged position, only that part of it which lies above the highest lake-level has a reasonable certainty of permanence. This, no doubt, explains why the phenomenon, which is fairly common, is not more of a regular occurrence.

HALLEY'S TIDAL CHART

PROFESSOR J. PROUDMAN, F.R.S., Director of the Liverpool Observatory and Tidal Institute

THE full title of this chart is: "A New & Correct Chart of the Channel between England & France with considerable Improvements not extant in any Draughts hitherto Publish'd; shewing the Sands, Shoals, depths of Water and Anchorage, with y^e^ flowing of the Tydes, and setting of the Current; as observ'd by the Learned D^r^ Halley. Sold by Mount & Page on Tower Hill London." The legend states: "In this Channell Draught, the smaller Figures are the Depth in Fathoms, The Litteral or Roman Figures shew y^e^ Hour of High-Water, or rather y^e^ End of the Stream, that setts to y^e^ Eastward, on y^e^ Day of y^e^ New & Full Moon. Add therefore y^e^ time of the Moon's Southing or Northing to y^e^ number found near y^e^ place where yo^r^. Ship is, & y^e^ Sum shall show you how long y^e^ Tide will run to y^e^ Eastward. But if it be more than 12 subtract 12 therefrom. The Direction of y^e^ Darts shew upon what Point of y^e^ Compass y^e^ strength of y^e^ Tide sets.=All Masters of Ships and others, who shall have opportunity to observe y^e^ Depths, with Certainty in respect of y^e^ Place, are desired to communicate them to y^e^ Publisher hereof."

The lengths of the arrows (Darts) do not appear to indicate the speeds of the tidal currents, but only directions. As the tidal currents are at many places rotatory, these directions are probably those for which the speed has maximum values. The other element of tidal information is the hour, on days of New and Full Moon, at which the current ceases to have a component in the direction of the arrows. This concept is not very precise, as the New or Full Moon may occur at any time of the day, and then there will be two times, not differing by 12 hours exactly, at which the component ceases. But in one form or another the idea of using days of New and Full Moon has been very extensively followed, especially for tidal heights.

There are 32 arrows and 56 times distributed fairly uniformly over the area of the Channel, but the times do not, as a rule, appear to be associated with the same places as the arrows. The chart contains no information as to how the observations were taken.

The observations on which the chart was based were carried out in 1701 between June and October on the Admiralty "pink" *Paramour*, Halley himself being in command. Certain of Halley's letters relating to the expedition have been preserved and published (1). These letters show that Halley himself drafted the instructions which were to be incorporated in the Admiralty orders to him. The instructions include: "to inform your self of the precise times of High and Low Water," but they do not include any independent mention of the end of the stream that sets to the eastward. This, together with part of the chart's legend, quoted above, seems to imply that Halley considered high water to be approximately simultaneous with the end of the east-running tidal current at the same place. Now over most of the English

Channel high water occurs several hours (2) before the end of the east-running tidal current, while, as will be seen below, Halley's times are in approximate agreement with modern determinations of the times of the end of the up-channel tidal current. Hence we may conclude that Halley measured the time of the end of the up-channel tidal current and not the time of high water. Away from land it is very much easier to measure the former than the latter. For both observations anchoring is necessary, and Halley's letters show that he did in fact anchor at many stations. The opinion that the end of flood is simultaneous with high water seems to have been generally held by seamen until the middle of the nineteenth century, and it is possible that Halley, through his statement on this chart, has some responsibility for its general acceptance. The supposed relationship is right when tidal currents flow straight in and out of a bay, but in general it is quite wrong, as was emphasized by F. W. Beechey in 1848 in his work on the tides of the Irish Sea. That it must be wrong was clear from the mathematical work of Lagrange and Laplace in the latter part of the eighteenth century.

So far as I am aware, Halley's chart is the first of its kind for any sea, and I do not know of any publication on similar lines until those of Beechey. This naval officer published papers in the *Phil. Trans.* of the Royal Society for 1848 and 1851. The first of these papers was mainly on the Irish Sea and contained charts relating to the tides and tidal currents of both the Irish Sea and the English Channel; the second was on the English Channel and the North Sea and contained charts relating to the tidal currents of both these regions. These charts contain continuous lines, the tangents to which correspond to the arrows of Halley. Surveyors of the British Admiralty had recorded observations on tidal currents at least as early as 1812, and Beechey also quotes the work of French hydrographic engineers in the English Channel.

From 1928 the Admiralty has carried out a re-survey of the tidal currents of British waters, and results of this re-survey have been incorporated in the Tidal Stream Atlas published by the Hydrographic Department. This Atlas contains 13 charts corresponding to phases of the tides at 13 successive hours, chosen in reference to high water at Dover. We shall compare the information given on Halley's chart with that in the latest edition (1942) of the Tidal Stream Atlas for the English Channel.

The directions of Halley's arrows are, on the whole, parallel to the central line (curve) of the Channel, and they agree generally with the directions of the maximum velocities given in the Admiralty Atlas. We now examine the times given on Halley's chart and consider points in the Channel lying on a series of transverse lines. We consider three points on each transverse line: (1) near the northern end, (2) near mid-channel, and (3) near the southern end. In order to bring the Admiralty times into Halley's form, it is necessary to assign a "time of high water at Dover on days of New and Full Moon." For this we shall take 11 hours, a time which is rather early.

In the Gulf of St. Malo both Halley's hours and the Admiralty hours reach the early value of $6\frac{1}{4}$. In the Spithead both Halley and the Admiralty give the hour 9. Halley's 5 off the Lizard is an approximation to the hour of high water on shore.

The "Hours on days of New and Full Moon" at which the Tidal Current ceases to have a component directed up-channel are respectively:

	Halley			*Admiralty*		
Transverse Lines	(1)	(2)	(3)	(1)	(2)	(3)
Lizard to Ushant	5	7	5	8	8	6
Start Pt. to Ile de Bréhat ..	8½	8¼	7½	9½	8½	6½
Portland Bill to C. de la Hague	10	10	9½	10	10½	10¼
St. Catherine's Pt. to C. Barfleur	11	11	11	10½	11	10
Selsea Bill to le Havre ..	10½	10½	9	9½	11½	10½
Beachy Head to Dieppe ..	11	11	11	11	12	12
Dover to Calais		15			15½	

On a straight line joining Winchelsea to Berck, Halley printed "Here the Two Tides meet." The different charts of the Admiralty Atlas give details of the meeting and separating tidal currents, and show that the phenomena occur from one end of the channel to the other. Consider a particular time and draw a curve through all the points at which the up-channel component of tidal current ceases at this time. Such a curve will cross the Channel. To the west of it the tidal current will already be running down-channel, while to the east of the curve the tidal current will still be running up-channel. Along any such a curve therefore the tidal currents may be said to separate, and half a tidal period later they may be said to meet. As the hours, "on days of New and Full Moon," increase from 8 to 12, the mid-channel part of the curve travels from the first to the sixth of the transverse lines given in the above table. But as the hours increase from 12 to 15½ the mid-channel part of the curve only travels from the sixth to the seventh transverse line. Hence, in the restricted part of the Channel between the sixth and seventh transverse lines, the tidal currents may be said to separate over a period of 3½ hours and to meet over an equal period. This restricted region contains Halley's line of meeting. That in this one region there is either meeting or separation over half the tidal period is a fact worthy of special note, and one which has very often been specially noted. But Halley's statement, and many subsequent statements, are exaggerated in that the line of meeting is not fixed and that for nearly half the tidal period there is neither meeting nor separation in the immediate neighbourhood.

Three facts emerge from the above and provide striking evidence for Halley's great qualities as a scientific pioneer. The first is that his investigation came over a century before extended investigations of a similar nature; the second is that his chart came a century and a half before other similar charts; and the third is that the information on his chart is in rough agreement with the much more complete information now available.

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SUGGESTED PRINCIPLES FOR THE USE AND SPELLING OF GEOGRAPHICAL NAMES—PART I

M. AUROUSSEAU, Secretary, P.C.G.N.

CONSIDERATION of such nouns as gallicism, china, sinology; such adjectives as Persian, Florentine, Muscovite, Hibernian; such verbs as to romanize, to anglicize, will show that geographical names contribute to the growth of the English language. They should claim the responsible attention of British geographers.

The Permanent Committee on Geographical Names for British Official Use has published no principles of nomenclature other than those contained in its rules for spelling, which were last revised in 1932. Some of His Majesty's Services and Departments of State have limited rules or regulations adapted to their own needs, but the rules of one Service or Department do not necessarily agree with those of another. In such circumstances, regularity in public observance can hardly be expected, and on the same day, 29 August 1942, a Russian town was reported in London as Rzhev by *The Times*, as Rjev by *The Daily Telegraph*, and as Rzheff by *The Evening News*.

The difficulties of geographical nomenclature are of such long standing that any proposals advanced require the most cautious consideration if settled practice worthy of the English language and of British geography is to be established. It should be clearly understood however that the suggestions advanced here do not represent the considered views of the Committee. In their present state they are merely open for consideration.

The Committee, besides having the experience and records of nearly a quarter of a century of its own active work in close association with those branches of His Majesty's Government most concerned with geographical names, and with the Royal Geographical Society, has now examined and compared the rulings and decisions of official authorities throughout the world.

A draft set of working-principles of geographical nomenclature was therefore prepared, and sent to all Representatives on the Committee before the Meeting of 8 April 1942 for consideration and criticism. It was subsequently offered to specialists who have work in hand, as an aid to the solution of their immediate difficulties. It has since been discussed with the Staff of the Royal Geographical Society and of the P.C.G.N., who suggested changes in presentation and the addition of more examples. It is now offered for criticism. Comment should be sent to the Secretary, P.C.G.N., at the House of the Society.

Principles of nomenclature

1. By geographical name shall be understood a proper name, dedication, designation, description, or title, or that part of a proper name, dedication, designation, description, or title, which serves, in a particular context of place, time, language, speech, or writing, to distinguish a particular geographical entity from all other things.

i. Any part of the world, feature of the earth's surface, organic aggregate: coral reef, forest, tribe, sect, race, communion, etc., or bounded unit of organization: state, part of a state, diocese, city, borough, farm, etc., is a geographical entity.

ii. In strict sense many so-called geographical names are not names. King George VI Sound and Mount Misery are *dedications*. The commemoration of deities, saints, monarchs, events, and circumstances, by geographical dedication is a common observance. Bay of Naples is a mere *designation* of a thing by reference to something else. Long Island is merely a *description*. United Kingdom of Great Britain and Northern Ireland, Commonwealth of Massachusetts, and République et Canton de Genève are *titles*. (The titles of states should not be confused with the names of countries.) Dedications, designations, descriptions, and titles are transformed into true proper names only by long historical wear and tear.

iii. Any geographical entity may bear different "names" at different times, *e.g.* Christiania—Oslo, or in different languages, *e.g.* Channel Islands—Iles Normandes; Cape Town—Kaapstad.

iv. At a given time a geographical entity may bear several names of different status, *e.g. popular*, Hull; *official*, Kingston upon Hull; *conventional*, Geneva (in English context); *international-postal*, Piréefs (English transliteration "Piraiévs").

v. A geographical name may be *simple in structure*, *e.g.* London; or *compound*, *e.g.* Isle of Wight.

vi. A geographical name may have a *generic part*, usually a common noun, *e.g.* Cape; and a *specific part*, which may be a proper or common noun, an adjective, or a phrase, *e.g.* of Good Hope. In some languages, *e.g.* Turkish, the generic part may be modified, and in many languages the specific part may be inflected.

vii. A geographical name may be *indefinite* or *definite* in *character*. We print Atlantic Ocean (indefinite) on British charts, but we say and write The Atlantic [Ocean] (definite). The distinction between indefinite and definite character may be very important, as in Albanian, Romanian, the Scandinavian languages, etc.

viii. A geographical name may have: a *short form* for local use, *e.g.* Newcastle for Newcastle upon Tyne; a *familiar form* for vernacular use, *e.g.* the City, *i.e.* of London; the Borough, *i.e.* of Southwark; a *contracted* or *abbreviated form* for use in special circumstances, *e.g.* Md. for Maryland; or *alternative forms*, *e.g.* Cape Town and Capetown. The last appear where different official authorities act independently.

2. Explorers, travellers, or surveyors, who propose names for geographical features not previously known by name to any people, should not suggest personal or fanciful names, and should publish the names proposed only with the approval of the government in recognized control over the country or region concerned.

3. Explorers, travellers, or surveyors, when recording unwritten geographical names in the field, should endeavour to write them in the script of the International Phonetic Association, at the dictation of several independent and enlightened speakers, and should then check them by reading them aloud to unprejudiced judges. When corrected, they may be transcribed into the British conventional alphabet, which will be considered in the November *Journal*.

4. Explorers, travellers, surveyors, and officers of H.M. Services abroad, when transmitting information about written geographical names to British government authorities, should endeavour to render local pronunciation in the script of the International Phonetic Association or in the conventional alphabet, and to supply native and official forms written by scholars in native and official script.

5. In speech, in popular prose-context, and on maps of scale not exceeding, say, 1 : 3,000,000:

a. The name of any part of the world, geographical feature, or place which has an English or conventionally-English name established in our literature, *e.g.* Damascus, shall be that name.

ix. The limiting scale is that which separates general from detailed maps in good reference-atlases.

x. Acceptance of 5a would oblige the P.C.G.N. to prepare a list of English names of places and features abroad.

b. The name of any other geographical feature or place shall be the name used by the recognized sovereign, dominion, colonial, or mandatory government over the region in which the feature or place is situated, if it be written officially in a form of the Roman alphabet; *or*, a broad transliteration of that name, if it be written officially in a non-Roman alphabet; *or*, a broad transcription, if it be written in non-alphabetical script;

provided that, if the foreign name be not easily assimilated to English speech or typography, or, in its original, transliterated or transcribed form, be misleading, it may be rendered in English form.

xi. We have the limited choice of taking foreign names *directly* from forms of the Roman alphabet; or of rendering them *letter-for-letter*, *i.e.* by transliteration, from foreign alphabets of Roman or non-Roman form, *e.g.* Dhodhekánisoi; *sound-for-sound*, either by ear from any language, or by transcription from any foreign alphabet or script, *e.g.* Ar-yól from (Russian) Orël; *by translation*, if they have meaning, *e.g.* The Twelve Islands from (Greek) Dhodhekánisoi; *by putting them into English form*, which is difficult; or *by turning them into English names*, *e.g.* The Dodecanese, which usually takes generations of wear and rarely happens spontaneously.

xii. In rendering foreign names it is most important to prevent the unnecessary multiplication of names, the growth of linguistically hybrid names (*e.g.* Aq River from Aq Su, which means White River), and the production of pleonasms (particularly common on some Russian maps. *Lake* Winder*mere* would be a pleonasm. The expression "the twelve Dodecanese Islands," *i.e.* the twelve Twelve-islands Islands, which appeared recently in an authoritative publication, is an excellent example).

xiii. It is also important not to impede the identification of things named by producing unfamiliar forms of their names, nor to break the continuity of our records by upsetting alphabetical order.

xiv. Acceptance of 5b would help in the elimination of diverse systems of romanization and transliteration from maps of intermediate and small scale, particularly such as appear in newspapers, ordinary books, and elementary school-atlases. It would make the more difficult foreign names easier for English people to pronounce and understand: the Croat name Cetinje could be rendered Tsetinye, and non-Roman letters, such as are used in Icelandic and Maltese, and troublesome diacritical marks, such as occur in Czech, would not appear. It means that children, and the public, would learn, in passing from the use of elementary to advanced atlases, that names are written in foreign ways abroad. This in turn would prevent the introduction of pleonasms and of linguistically-hybrid names into English.

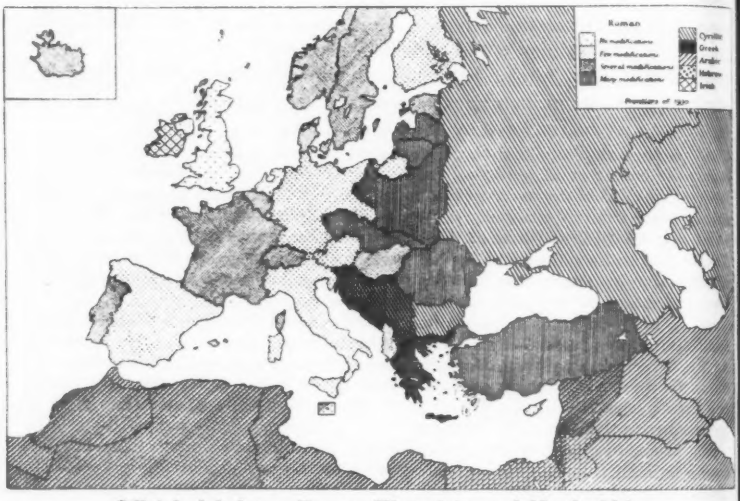
c. By English form shall be understood: broad transliteration or broad transcription of the names of inhabited places and of *simple* names of geographical features; and the translation of the generic element in the *compound* names of natural features, and the grammatical combination with it, when possible, of a broad transliteration or broad transcription of the essential part of the specific element, *e.g.* Gulf of Argolis from (Greek) Argolikós Kólpos.

xv. Foreign names can be put into satisfactory English form only by persons with a considerable knowledge both of English and of the other languages involved, and of geography. The procedure follows no simple rule. The example given above, for instance, would also yield Argolic Gulf, which is nearer the Greek but barbarous in sound. Some names are impossible of treatment, for grammatical reasons.

xvi. When successful, this procedure makes for the closer assimilation of foreign names to English, and contributes therefore to the slow development of more English names. *The Times* printed the Turkish word "Cümhuriyet" in the English form of "Jumhuriet" on 29 August 1942.

d. By broad transliteration or broad transcription shall be understood: the approximate rendering of the most generally used native pronunciation, in the conventional alphabet, *e.g.* Iraq, Ed Daba (for the written Arabic El Daba).

e. It shall be stated on maps and charts that the foreign forms of many names differ from those given.



Official alphabets:: Europe, West Asia, and North Africa

6. In learned prose-context, and on maps and charts of scale larger than, say, 1 : 3,000,000:

a. The name of any marine feature which lies beyond the territorial limits of recognized government and has an English or conventionally English name shall be that name.

xvii. This too would oblige the P.C.G.N. to issue a list of English names.

b. The name of any natural feature of international interest which has an English name shall be that name, provided that, if its foreign official names differ markedly from the English, they may be shown in brackets after it where necessary.

xviii. In practice, this simplifies the treatment of coastal and frontier-names.

c. All other geographical names in countries which normally, *e.g.* Spain, or officially, *e.g.* India, Yugoslavia, use a form of the Roman alphabet shall be adopted without change in the form, alphabet, and spelling used by the authority responsible for the official survey, or, failing that, in the best ascertainable official form.

d. All geographical names in countries which normally use non-Roman

script but make auxiliary use of satisfactory systems of romanization, *e.g.* Egypt, shall be accepted in that romanization.

e. All geographical names in countries which officially use none but non-Roman alphabets or scripts, or unsatisfactory auxiliary systems of romanization, shall be rendered from the native script in narrow transliteration or narrow transcription.

f. By narrow transliteration or narrow transcription shall be understood: from alphabetical script, transliteration, in the conventional alphabet, strict enough to preserve the appearance of written words and to maintain their place in alphabetical order wherever possible, *e.g.* Al 'Irāq, El Daba; or from non-alphabetical script, transcription precise enough to render words intelligible to natives when read aloud by Englishmen.

g. Such English or international-postal names of important places as differ markedly from the foreign official names affected by 6c, d, and e, may be added in brackets, if necessary.

h. It shall be stated on maps and charts that foreign names are rendered directly or indirectly from foreign forms.

i. Notes on pronunciation and glossaries of terms used shall be given on the margins of sheets which cover foreign territory.

xix. The P.C.G.N. is preparing a series of glossaries for official use, of which two have already been issued. The series will be of great help to those studying geography in difficult languages.

7. In historical context the name of any part of the world, geographical feature, or place, shall be the name, or a narrow transliteration or narrow transcription of the name, which it bore in the language which prevailed in the region, and at the time, under consideration; *or*, the name by which it is conventionally known to English scholars;

provided that, the modern name, or a narrow transliteration or narrow transcription of the modern name, should also be given, if necessary. Transliteration or transcription of ancient names shall be according to systems approved by recognized authorities on the languages concerned.

(Part II. The system of orthography will be considered in the next number of the *Journal*.)

REVIEWS

EUROPE

PEASANT LIFE IN JUGOSLAVIA. By OLIVE LODGE. *London: Seeley, Service*, 1942. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches; 332 pages; illustrations.* 21*s*

This book gives a comprehensive, detailed, and graphic account of every aspect of peasant life in those parts of Yugoslavia where western influence has penetrated least: chiefly, that is, in Old Serbia. The author spent many years living and travelling in these parts, and studied the Yugoslav people usually with sympathy.

A preliminary summary of the country's history not only explains many of the national customs, but shows how, during the centuries of subjection after the great Serbian lords had perished in the fourteenth century, peasant life was the only life which survived. To-day, even the most westernized town-dweller is the son or grandson of a peasant, and recognizes his peasant cousins as his equals. The peasant life of Yugoslavia is still the true life of the country.

The influence of western civilization is only slowly penetrating to the Yugoslav villages, bringing with it modern amenities, but often destroying much that is picturesque. Home life and customs, the village crafts and industries, the work in the fields, and the songs and ballads sung by the people remain unchanged, though the village children now go to school, medical attention is available for everybody, and there may be a railway within walking distance.

The large family community known as the *zadruga*, living under one roof, still exists in some parts of Old Serbia. The author describes the individual work of each member in the house or fields. Such households are practically self-supporting, as are often the smaller peasant landowners', for they may produce everything to supply their needs, even to their own tobacco and wine, and spinning and weaving are home industries in villages remote from towns. The fullest description of methods of ploughing, and of the sowing and harvesting of the many and varied crops, is given, often enlivened by picturesque details. Every type of peasant home is described, from the most primitive mountain cottage in the remote districts of Serbia, Montenegro, and Hercegovina, where family and animals sometimes sleep in one room, to the pleasant, colourful houses of the Moslem Slavs.

A chapter is devoted to descriptions of the elaborate national costumes, which vary according to the district, and sometimes show Greek, Turkish, Albanian, or German influence. These costumes are of as much interest to the Yugoslav town dwellers as to the western European sightseer, for they are seen only in the villages.

The recently built Orthodox churches are usually simple, small, and humble; but some of the more elaborate and imposing churches built by the Serbian kings before the time of the Turkish domination have withstood the ravages of Turks and Bulgars. There are detailed descriptions of these and of the famous monasteries, notably the twelfth-century monastery of Studenica, and that of St. Petka—converted into a mosque by the Turks, by the addition of a minaret, which was later removed by the Serbs. Ceremonies connected with church feasts vary in different parts of the country, as do many curious customs of everyday life which are based on superstition and religion. Details of many of them are given.

There is so much information on so many and varied subjects in this book,

that it cannot fail to interest a wide circle of readers, by no means restricted to those who are particularly interested in Yugoslavia or ethnology. V. J.

AFRICA

EUROPEAN POWERS AND SOUTH-EAST AFRICA. By MABEL V. JACKSON. (Royal Empire Society, Imperial Studies, No. 18.) *London: Longmans, Green*, 1942. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* viii+284 *pages; maps.* 21*s*

This study, more precisely defined in the sub-title as one "of International relations on the south-east coast of Africa, 1796–1856," is a solid piece of work based on research not only in the Public Record Office and other repositories of original documents in this country, but also in the Portuguese Archives. The period dealt with is comparatively short, and being devoid of spectacular events in the region in question, extended northward to include the Zanzibar Coast, the story has perhaps attracted less general attention than that of other parts of Africa. The author's remark however that it "has been allowed to remain enshrouded in a haze of obscurity" is surely rather too sweeping. Though the subject is here treated in relation to World-politics and sea-power in general rather than as a mere local episode, the wider aspect has not hitherto been entirely neglected, having been suggested at least in Admiral Ballard's 'Rulers of the Indian Ocean' as well as in articles in the 'Cambridge history of the British Empire,' and works by Professor Coupland.

The main theme is the rivalries of the European Powers, and in a less degree of the United States, in regard to the Eastern trade generally, and their aims to safeguard the sea route to the East through the Indian Ocean; as this passes athwart the African coasts these gained more than a mere local importance. While keeping a jealous eye on such foreign moves as might definitely threaten British interests, the government at home was shy of accepting any territorial responsibility, paying attention chiefly to what might help towards suppressing the slave trade. Even the far-sighted action of Captain Owen in securing a protectorate over Mombasa found no support, and similar efforts at Delagoa Bay, which Owen regarded as the natural gateway into the interior, led to no result. Both here and at Mozambique (the acquisition of which was urged in 1807 by the East India Company) British interests clashed mainly of course with Portugal, but also to some extent with those of France and the United States, and on this part of the subject (with some reference to the domestic economy of the Portuguese territory) Dr. Jackson's researches have no doubt thrown new light, as they have in general on the details of the story, where its main outlines have been well known. In regard to the Zanzibar coast she struck a rich mine in the Foreign Office correspondence on Muscat now in the P.R.O.

A bibliography is given, and is valuable chiefly as a guide to the official documents most useful for a study of the subject. The list of general works makes no claim to completeness and is somewhat strangely appended to the section headed Foreign Office Library. One or two of the entries need amendment. Thus Barbosa's well-known work is quoted in the original Hakluyt Society edition of 1865, the greatly improved second edition of Mr. Longworth Dames (1918–21) being ignored; and Pyrard's 'Voyage to the East in 1601–11' is quoted in a Portuguese edition of 1858–62, no mention being made of Sir Albert Gray's excellent English edition of 1887–89. A distinct merit of the book is the careful reference to sources, almost every important statement being vouched for by mention in footnotes of the particular document authorizing it. E. H.

NORTH AMERICA

AMERICAN HAZARD. By P. W. RAINIER. *London: John Murray*, 1942. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches; 262 pages.* 10*s* 6*d*

Mr. Rainier went to the United States in 1919 to seek the capital necessary to buy land in South Africa; and if he did not succeed in getting it, or rather of retaining it when he had got it—as apparently he did at Miami—he can at least show a thoroughly readable book as one outcome of his search.

A great engineering works at Milwaukee, construction camps in Pennsylvania, a gold-mining venture in Texas, and Miami, the Everglades and the Florida coasts were the successive scenes of the experiences that he describes. And these, with their first-hand accounts of such features of contemporary American life and social history as boot-legging; strikes; American trade unionism, with its strong nationalistic tinge; the competitive methods employed by Big Business; the Florida land boom, the hurricane that ended it, and life in the Everglades, provide excellent material not only for the general reader but for those who wish to realize what the practical working conditions in other countries actually are. E. DE B.

POLAR REGIONS

REPORTS UPON THE GREENLAND EXPEDITIONS OF THE University of Michigan. Part II. Meteorology, physiography, and botany. Edited by W. H. HOBBS. (Vol. 6 Univ. of Michigan Studies, Scientific Series.) *Ann Arbor: Univ. of Michigan Press*, 1941. (*London: H. Milford.*) 11×8 *inches;* viii+288 *pages; illustrations, sketch-maps, and diagram.* $5.00 (28*s*)

This is the concluding volume of the University of Michigan reports and covers scientific studies made on the western seaboard of Greenland during the years 1926–33. The meteorological work of 1932–33 was directed by Dr. Belknap, most of the remainder by Professor Hobbs.

The volume consists of five unconnected sections:

(I) *Meteorological studies by J. E. Church*

For his alpine data Professor Church has selected his well-known observations in the Lake Tahoe basin of the Sierra Nevada group on the borders of the States of California and Nevada. These he had made several years before, during the course of his successful work in forecasting run-off of water into the rivers by surveying and calculating the amount of the winter snow-cover in the catchment areas. It is disappointing that no comparison is made between the evaporation rates in this and the Greenland zones. The rate at which a layer of snow evaporates depends, *inter alia*, on one factor not mentioned in this paper, namely the age or specific gravity of the snow, for the minute crystals of very new snow are far more sensitive to the principal agents of evaporation than those of older, more compact snow. This accounts perhaps for occasional rather puzzling results; it seems meaningless to compare the rates of evaporation of ice and snow without giving the specific gravity or defining the condition of the latter. The term Foehn as applied to Greenland winds is also a little confusing. Professor Church's water temperatures and much of his other work are very interesting and valuable.

(II) *Report of the Northern Division of the Fourth University of Michigan Greenland Expedition, 1930–31, by William S. Carlson*

This expedition was based on Upernivik on the western coast of Greenland, in latitude 72° 47′ N., to study the atmosphere "at all possible heights." A complete set of meteorological observations was made including a large number of

pilot-balloon ascents to record wind speed and direction in the upper air. Tailless balloons appear to have been used, having theoretically a constant rate of ascent. Heights up to 12,500 metres were reached. The resulting frequency tables should be of great help in unravelling the complex weather conditions in and around the great ice mass of Greenland. Dr. Carlson's research has given much new information about the circulation of the air in that district, but it is a small district only and, as he himself remarks, the extent of these influences cannot be finally determined until synchronized observations are made in several regions, notably eastern and western Greenland, western Iceland, and Baffin Land. That the influence of Greenland may be smaller than has been suggested is possible, for even when a wider knowledge of that country has been attained it forms only a very small part of the three dimensional meteorological scene.

Dr. Carlson adds a note on the geology of the marginal area in the Upernivik region, but a journey in a region partially covered with snow does not provide ideal conditions for the geologist. This makes the survey all the more creditable. Measurements were also made of the speed of flow of the Upernivik Glacier near its tongue. Dr. Carlson noted an average speed of nearly 60 feet a day at its fastest point. The comparisons he gives with Captain Ryder's measurements, while interesting, do not carry us very far since the latter were only made over a short period in 1886 and 1887, and at points often thousands of yards distant from those under review, for the glacier, like several others in the neighbourhood, has receded considerably.

(III) *Meteorological report of the University of Michigan Pan American Airways Greenland Expedition August* 1, 1932–*July* 31, 1933, *by R. L. Belknap*

This expedition was centred on Upper Nugssuak in the Upernivik area with an auxiliary station, Camp Watkins, nearly 200 miles inland on the central glacier at a height of 8840 feet, its position being noted as 74° 40′ N., 47° 30′ W.

Dr. Belknap's observations, particularly those of the incidence and movement of depressions, contain much valuable material including some instructive correlations with those of other districts. He reaches the conclusion that the view previously entertained by some that depressions first observed in south Greenland travelled up both coasts did not tally with his own findings, and that they either moved northwards along the east or the west coast or that separate disturbances moved along both coasts simultaneously. Dr. Belknap's more orthodox remarks about the foehn come rather as a relief. Precipitation figures in districts where a large proportion is in the form of snow must always be somewhat suspect for no really reliable method of measuring snowfall exists. In particular measurement by driving in stakes is bound to be crude, since it can take little account of wind erosion and none of the perpetual sinking or settling of the surface which even in firn snow of advanced age is differential and considerable. But this is a minor criticism amid high appreciation of some excellent records.

(IV) *Physiographic studies in the Holstenborg District of southern Greenland, by R. L. Belknap*

Holstenborg is situated on the western coast of Greenland, a little over 400 miles south of Upernivik, and lies just north of the Arctic Circle. It is not quite clear at what period this research was undertaken but presumably it formed part of the expedition noted above. Its main object was the geological description of the area. The predominant rocks were pre-Cambrian gneisses with basic intrusions. The whole area, as is to be expected, is glaciated and must have come under the influence of the central ice mass, although the coastal zone itself gives evidence of the action of local glaciers. The district is much faulted, the

faults often being very conspicuous. Dr. Belknap attributes the outline and direction of the valleys to fracture rather than to any schistose structure in the rocks. There are also many signs of block faulting which, Dr. Belknap maintains, could have caused and would satisfactorily explain the double tier along the coast with its reef and island formation. This paper, too, impresses by its competence and clarity.

(V) *The vascular plants of an inland region within the Holstenborg District of west Greenland, by Carl O. Erlanson*

The collection of papers is concluded with a study of the flora in the inland district at the head of the Söndre Strömfjord. Dr. Erlanson confined his studies to the vascular plants, thus omitting the mosses and liverworts and the whole group of the Thallophyta which includes the lichens. He records however that a member of the genus Sphagnum, one of the bog mosses, is dominant over a small area.

The plant communities examined are mainly associated with three regions: heath, bog, and the barren Fjaeldmark, a feature of Arctic regions. The last is especially interesting since the plants are so widely dispersed that there is little or no competition between them as in closed communities and such competition as exists is between individual plants fighting for their existence against their unfavourable environment.

Dr. Erlanson lists members of some 33 natural orders and 130 species, many of which are well known to British growers of alpines. The only representatives of the vascular cryptogams in the collection are members of the natural orders of the Fern family and several species of the genus Equisetum, the horse-tails; all the rest are flowering plants. The natural orders most numerously represented are the Gramineae, the grasses, and the Cyperaceae or Sedge family. In this latter the genus Carex is predominant, a genus with some fifty species in Great Britain.

Only one other collection has been made in the district, that of J. A. D. Jensen in 1884. This contained five species not found by Erlanson, but it is not mentioned whether all the plants in the collection of the latter were enumerated by Jensen. Within the limits covered by the investigation, Dr. Erlanson's paper is short, precise, and admirably to the point.

This volume, which adds yet another stone to our mosaic of statistical knowledge, is well printed and the general get-up excellent. The illustrations include some very beautiful photographs, but the reviewer believes that the photogravure process handicaps all but pictures of superlative quality and that it is therefore unsuitable when some of the photographs have to be chosen for their scientific, rather than their pictorial, value. G. S.

CARTOGRAPHY

BARTHOLOMEW'S WORLD CONTOURED SERIES: map of Burma, Malaya, and Indo-China. Scale 1/4,000,000. *Edinburgh and London: John Bartholomew*, 1942. 32½ × 21 *inches. Cloth* 4*s* 6*d*

PHILIP'S REGIONAL WALL MAP OF THE FAR EAST. Scale 1/6,500,000. *London: George Philip*, 1942. 44½ × 34½ *inches. Mounted* 12*s* 6*d*

Students of the Far East will find these two publications extremely useful. The map of Burma, Malaya, and Indo-China includes an area extending from Singapore to Chungking and from the island of Hainan to the port of Chittagong in India. Relief is shown by layer-colouring in nine tints, with green for the lowlands and shades of brown, violet, and white for the mountainous regions.

The key gives the relief scale both in metres and feet, while spot heights on the map are in feet alone. The sea is coloured in two shades of blue, according to depth. In the selection of other symbols for this map care has been taken to avoid those which might confuse or dominate the relief, with the result that a good balance has been achieved between the physical and non-physical elements. Railways are indicated by black and roads (two grades) by red lines, with caravan routes in red broken lines. In addition to showing the Burma Road, the new supply route between north-eastern Assam and Chungking is also marked. International boundaries appear as a thick purple line, and, though clearly recognizable, they are not too prominent. A broken purple line shows the boundary changes made in 1940 following the negotiations between Indo-China and Siam. The lettering of natural features and of place-names is attractive and easy to read. Two insets increase the value of the map: the one is a map of Singapore island and the adjoining mainland (1/500,000); the other, on Mercator's projection, shows the position of Burma, Malaya, and Indo-China in relation with the other countries of the western Pacific region and with the land surrounding the Indian Ocean.

Philip's wall map of the Far East covers an area from Sakhalin to Port Darwin in Australia and from the Mariana and Caroline Islands to Burma. It is layered in seven tints, three green and four brown, the key to which is given in metres and feet. The layer-colouring, which has an irregular interval, presents a clear if necessarily somewhat diagrammatic picture of the relief. Layer tints, in blue, are also used for the sea and the five gradations bring out very well the great differences in sea depth over this region. Rivers and lakes are in blue. Railways are indicated by a red line; no roads have been included on the map, excepting the Burma Road, from Lashio to Chungking, which is shown by a thin, double, black line. Five different symbols are given for towns and cities, according to size. A dot-dash blue line, with red shading on one side, has been used to show the international boundaries. Certain parts are overburdened with place-names. The confusion of town symbols and overcrowding detracts from the value of the map. The map is on Bonne's projection. J. C. S.

ECONOMIC AND HISTORICAL GEOGRAPHY

URBANE TRAVELERS, 1591–1635. By BOIES PENROSE. *Philadelphia: University of Pennsylvania Press.* (*London: Humphrey Milford*), 1942. 8½×6 *inches;* x+252 *pages; illustrations*

Mr. Penrose is an American who, possessing a fine library of travel literature, has diligently studied his treasures and is now giving the public the benefit of his researches. Four years ago he published 'The Sherleian Odyssey,' in which he deftly summarized the considerable literature which has grown up round the three celebrated brothers; and now he has compiled what he describes as "in a sense a sequel," dealing with seven travellers who were more or less contemporary with the Sherleys. These are Fynes Moryson, John Cartwright, Thomas Coryate, William Lithgow, George Sandys, Thomas Herbert, and Henry Blount. In each case a full biography is given; but this is used mainly as a setting for a detailed narrative of the traveller's wanderings, the more interesting portions of which are described in his own words. The result is a volume not only informative but entertaining.

The epithet "urbane" was applied by Professor Eva Taylor to a class of sixteenth or seventeenth century travellers whose motives were neither religious nor commercial but rather those supposed to animate the modern "globe-trotter." Her definition was a wide one: "the man of culture who was touring

Europe to complete his education, or to satisfy his spi[rit] [cur]iosity, or occasion[ally] just to seek notoriety"; and this has enabled Mr. Penrose to include t[wo] travellers (Coryate and Lithgow), neither of whom had much urbanity, in th[e] modern sense of the word. However the term serves well enough to bi[nd] together a group of tourists who had much in common. None of them unde[r]took his journeys merely to make money; they all possessed the true spirit [of] adventure, and suffered patiently the hardships and risks inseparable fr[om] travel in those days; all published accounts of their experiences, which render[ed] a real service in spreading among their fellow countr[ymen] knowledge [of] foreign lands; and finally, most of them made the Levant a special feature i[n] their wanderings. Mr. Penrose deals out to each the same careful treatme[nt] though he is at his best in his account of Coryate, that eccentric mountebank who trudged as far as India.

The volume is provided with an index, a bibliography, and eleven well-chosen illustrations. A map would have been a welcome addition. W. P.

GENERAL

MAN AND HIS HABITATION: a study in social ecology. By RADHAKHAMAL MUKERJEE. (Lucknow Univ. Studies, No. xii.) *London: Longmans, Green*, 1942. (First published Allahabad, 1941.) 10×6½ *inches;* xvi+320 *pages*. 8*s* 6*d*

Professor Mukerjee writes that social ecology "envisages the differences in man's psychic organization, social aptitudes and institutional relationships in terms of his spatial and food relations to the land, to the mechanical-technic base, and to fellow individuals. . . . While the ecological whole situation outlook may be a corrective of the neglective procedure of the specialized social sciences, it also supports a wide-minded coordination of mechanical-technic with regional and social planning, without which neither the evils of power-technology nor the urbanized habits of the social group, both of which we seem to accept as the indispensable equipment of civilised existence, can be adequately counteracted." The quotation shows the purpose of these lectures; unfortunately it also shows the author's habit of piling up adverb upon adjectival noun which obscures the very outlook which he wishes to point out and interpret.

Is the search for such an outlook justified? it may be asked. Is so wide an outlook desirable and, if so, is its attainment possible and practicable? In the first place Professor Mukerjee's plea for his outlook begins with the charge that the "procedure of the more specialized social sciences," though no doubt one of selection in the main, also "neglects" vital matters. In British geography and economics, this charge is all too true. Economics has only recently awakened to the value of geography. Sociology is only slowly finding a footing in our universities. And British geography suffers from lack of adequate sociological collaboration.

The methods are those in general use in the United States, but the matter is that about which the author is most competent to write, and of which he has most to teach us: contemporary conditions and evolution of man and his habitation in northern India, which are concisely described. A final chapter envisages the principle of planned habitation in country and town. A. G.

THE MONTHLY RECORD

ERNANDO COLON

Two pamphlets have been received from that indefatigable student of the olón family, Señor Emiliano Jos.: both are reprints of articles published in e *Revista de Indias* during 1942, and each deals with controversial points in the airs of Columbus' son Fernando.

In the "Imp[illegible]nes a la 'Historia del Almirante' escrito por su hijo ernando Colón," Señor Jos refutes the attacks made by other writers, Harrisse d Carbia particularly, on Fernando Colón's authorship of the 'History of the dmiral'; the facts that Fernando, as far as is known, never mentioned or owed the manuscript to anyone; that he did not include it in his list of books d manuscripts in his library; that there are strange factual errors in the istory, and that nothing was heard of it until twenty-two years after Fernando's eath (it was published in Venice in 1571) form the basis of doubts; but Señor s attacks the attackers with his usual spirit. The second article, "Centenario e Fernando Colón," is concerned with problems of Fernando's veracity hich, Señor Jos admits, was occasionally severely strained for motives con-ected with the intricacies of the long years of litigation between Colón's escendants and the Spanish Crown: the former trying to establish themselves heirs to the enormous possessions and privileges originally granted to ristóbal Colón, and the Crown trying to obtain relief from the consequences f the literal interpretation of these grants, made at a time when no inkling of e huge size and wealth of the New World had dawned upon Europe.

STUDY OF SETTLEMENTS

Professor Griffith Taylor's presidential address last year to the Association f American Geographers, published in the *Annals*, March 1942, dealt with Environment, village, and city." It is based upon a study of seven settlements nging through all latitudes and of three cities, Canberra, Sydney, and Toronto, eir development being analysed in relation to environmental and human ntrols. The author states the arguments for both influences fairly, and con-ludes that the human factor is more marked in smaller groups, though con-nuing to hold that the general distribution of population in the past has been termined almost exclusively by the environment. On the whole question of ographical determination however he has advanced some way to meet his pponents, and this formerly warmly debated issue seems now to be merely a atter of emphasis and phrasing. For instance, he now regards the determinist a "long range planner" seeking for the best plan among those possible: here rely the "possibilists" whom he derides can claim the same aim, provided man needs and techniques receive due consideration. They could also urge ny instances where, for example, through wasteful exploitation of natural sources, the population in particular regions has come to be distributed thout relation to the inherent potentialities of the environment, or has been nsiderably modified by external economic changes.

CIENTIFIC EXPEDITIONS IN BRAZIL

We have received by the courtesy of the Foreign Office a statement of the rganization of The Supervisory Council of Scientific and Artistic Expeditions Brazil, and several copies of the relevant questionnaire. The Council, con-ituted in 1933, has as President the Director of the Forestry Service, and eight epresentatives of national ministries: its approval must be obtained by all

expeditions wishing to enter the country. The questionnaire to be submitte to it requires details of all members of the expedition; a statement of the aim and the proposed itinerary in full; the institutions for which collections are t be made; the instruments and materials to be used; and a declaration that th members undertake to obey the laws of Brazil and the regulations of the Council. Permits are issued in the first instance for one year, and a fres application must be made for an extension. Before any specimens are sent ou of the country they must be examined by a member of the Council, who wi issue the necessary Customs declaration. Members wishing to hunt or fis must also obtain permission from the Division of Game and Fisheries, and permit to carry arms from the police.

THE NANSEN CLUB IN LONDON

At a meeting of Norwegians and British held in London on Saturda October 10 it was resolved to form a Club, to keep alive the memory of Fridtj Nansen as a geographer and explorer and to cultivate his ideals of internationa cooperation. It is proposed that the Club shall dine annually on October 10 Nansen's birthday, and that its other activities shall include meetings, publica tions, and "extraordinary enterprises decided upon by a General Meeting." The seat of the Club is in London, and the number of permanent members limited to eighty-six. Further information may be obtained from Profess J. S. Worm-Müller at Kingston House, S.W.7.

SMITHSONIAN PAMPHLETS

The Smithsonian Institution is publishing a series of pamphlets under th general title 'War background studies.' In the first, C. W. Bishop outline clearly the origin of the Far Eastern civilizations, beginning with the growth Chinese culture in the loess districts of the Yellow River basin from palaeolithi times to the close of the Chou era, and its spread through the neighbouring land of eastern Asia. He emphasizes the persistence throughout of the neolithi population, subjected to invaders from the west and to successive waves influences along the steppe corridor from the nearer east, though not all th elements associated with the latter took root. The Bronze Age culture develope later and persisted longer than in the Near East, but without introducing dairy economy or the weaving of wool. Under the Chou regime there was priestly class, and the nobles firmly resisted committing their laws to writing these circumstances may account for the absence of an intellectual advanc comparable with that made in the Near East. However the question why pa ticular elements were adopted and others missed is not discussed here. I summing up the writer concludes that the civilizing role of China in Easter Asia is fully comparable with that assumed in the West by the Near Ea Greece, and Rome.

In the second study J. R. Swanton discusses the often-debated subject of th evolution of nations, and has no difficulty in showing that the limits of nation in many instances do not coincide with particular racial, geographical, o linguistic regions. In support he analyses briefly the history of a number ancient and modern states. He concludes that the dominating factor in the growth has been "a consciousness of kind" based upon a desire for economi well-being and aspirations for cultural and spiritual self-realization. Accepting the truth of this contention, it appears merely to move the problem one ste back, and to leave the question why this consciousness developed in certa areas unanswered. Some further light might have been thrown upon it by con sidering the growth of the modern idea of nationality. The idea that th

boundaries of a particular state should coincide with those of a language or a "people" developed in Western Europe in comparatively recent centuries. Like that of "natural frontiers" it was attractive to an expanding political organization such for example as seventeenth-century France. The application of the idea was thus often a conscious act. How far the coincidence could be made complete depended upon many subsidiary elements, geographical, economic, and historical.

THE RECTIFICATION OF AIR PHOTOGRAPHS

Mr. F. S. Richards, formerly of the Survey of Egypt, sends the following note:

The Canadian High Oblique Plotter, described in the *Journal* for August 1942, uses a very important principle which was also used by Cole in Mesopotamia in 1916 for the rectification of near verticals. His method of using the perspective centre of the photograph was this: His enlarging camera had a lens whose focal length was about $\frac{3}{5}$ of the focal length of the camera lens, and the first principal point of the enlarging lens was set at a distance from the negative equal to the focal length of the camera lens, which gave an enlargement of about 50 per cent. To take out the tilt it was necessary only to tilt the copyboard to the tilt of the plate at the moment of exposure, generally not more than one or two degrees, so that focus could easily be obtained by stopping down. The enlargement was then when necessary re-photographed to the scale of the mosaic. Photographs for a mosaic are usually made at a constant height; if there are two flights make two mosaics and reduce one to the scale of the other. As Captain Trorey says on page 59: "this expedient is not mathematically precise . . . but the error introduced is negligible."

In a covering letter Mr. Richards adds that for years he has held the opinion that the medium-scale maps of the future (say 1/10,000–1/100,000) will be photogravure reproductions of air mosaics with a very few overprints such as names in black; roads, railways, and conventional signs (the fewer the better) in red; and water in blue. The groundwork mosaic will need some attention from the artist; only experience can show how much.

KHAN TENGRI

The conspicuous appearance upon the British Council Map of Khan Tengri has led to an inquiry if it has been climbed. So far as we can find the only accessible accounts of its conquest in August 1936 are an article in *Le Vie del Mondo*, July 1938, p. 677, and another in the *Geographical Magazine*, September 1938, p. 343, by Annemarie Clarke-Schwarzenbach, who in May 1937 made a journey from Zurich to Moscow to recover the records of Lorenz Saladin. Born in 1896 in the Canton of Solothurn, Saladin had made some reputation as a climber by ascents in the Caucasus (*Alpine Journal*, May 1935) and had been a member of the Russian Pamir Expedition of 1935. In 1936 he formed the project of climbing Muztagh Ata or Khan Tengri, and being refused a *visa* for Chinese Turkistan, organized an expedition with four Russian climbers to the Tien Shan, supported by a grant of 15,000 roubles from the Central Office of the Trades Unions. They reached Karakol on August 7, and had difficulty with the frontier administration, since Saladin's tourist *visa* was not valid for the frontier; but after ten days' delay, and many telegrams to Moscow, the permit was granted, and the party marched with horses over the Terskei-Alatau range into the Sary Jas valley and then to the Inylchek glacier. Leaving the base camp (height unspecified) at 22.00 hrs. on August 30 they established bivouacs at 18700, 20300, 22000, and 23000 feet, sleeping without a tent in holes dug

in the snow. On September 5 they reached the summit (23,600 feet) and quickly returned to the 23,000 camp. Later they were overtaken by a severe storm; one of the party slipped 600 feet, and Saladin carried him back to below the first bivouac, where all the party were frostbitten but reached the base camp, and descended the glacier to meet their porters and horses. Saladin became ill from poisoning of his frostbitten hands and died on September 14. The four Russians were met on the same day by a rescue party summoned by their radio, and were flown back to Alma Ata.

The accounts from which we have made this brief extract are illustrated by good photographs of the journey and of the last bivouac, but none of the summit or the view from it.

OBITUARY

MAJOR B. T. WYN IRWIN, M.D.

Major Wyn Irwin, who died at Christchurch, N.Z., on March 12, two weeks after he had been invalided home from the Middle East, had been a Fellow of the Society since 1933. Born in 1905, his record as a medical student showed great distinction, followed by valuable work both in research and for the Public Health Department. He left New Zealand in the 1st Echelon, with the rank of Captain, as the Officer Commanding 4th Field Hygiene Section. Serving in the campaigns in Greece and Crete, and later as Senior Medical Officer at the Maadi Camp, he did much to improve the health of the troops and to lessen malaria.

He was always a keen mountaineer, interested in mapping rather than in high climbing, and was one of the original members of the Canterbury Climbing Club. Papers in the *New Zealand Alpine Journal* and the *Canterbury Mountaineer* show the result of his work. He contributed reconnaissance maps of the Poulter, Mingha, Edwards, and Waimakiri valleys, and was the first to cross from the Waimakiri to the Wilberforce by the White Col.

ELECTIONS

The following have been elected Fellows of the Society:

On 2 September 1942: Dr. William Stanley Carrick; Edmond Percival Fearnley; John Arnold Denain Grange; Major R. W. H. Jackson, B.A., M.D., D.P.H.; Mrs. A. Noel-Paton; Captain L. Douglas-Patterson.

On 28 September 1942: Major T. S. Blakeney; Arthur Gibson; Lieut. J. W. Burke Cole; G. D. L. Millar; Miss M. E. Pelly; Lieut. R. M. W. Powell, R.E.; Lieut.-Colonel D. W. Price, R.E.